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ANNALS *of* SURGERY

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No. 1

A NOTE ON THE TREATMENT OF COMPOUND FRACTURES OF THE SKULL WITH OPEN DURA

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THE treatment of fractured skull is a subject on which there still is considerable difference of opinion. Surgeons differ a good deal as to which cases should be decompressed and in which cases operation offers no prospect of relief. There is a group of border-line cases which frequently recover without operation, but whose symptoms are more quickly relieved by operation. In some of these cases operation obviates permanent disability due to persistent headache. With all such cases this paper does not concern itself.

Compound fractures of the skull in which the dura has been torn and the brain has been traumatized have always offered a grave prognosis and operation has always been considered serious because of the possibility of meningitis or a brain abscess.

The problem has received a new stimulus, however, since the reports have come in about the modern treatment of war wounds, especially since we have recognized the difference between contaminated and infected wounds. It seemed reasonable that these views which had been applied to wounds elsewhere in the body could also be applied to wounds of the brain. We were further encouraged in this view by attempts in the laboratory to produce brain abscesses. Repeated attempts to infect healthy brain tissue with virulent pyogenic organisms failed to produce abscesses. It was realized that devitalized tissue was probably an important factor in bringing about brain infection. Suitable cases for this work are rare in civil life as compared to the huge number of cases encountered among war wounds. Certain differences are furthermore apparent between these cranial wounds of civil life and those occurring on the battlefield. In a large percentage of cranial war wounds with open dura, foreign bodies are lodged in the brain substance, while in fractures occurring in civil life this is very rare. The injury, furthermore, in the latter type of cases, is more apt to involve the cortex and subjacent area but does not extend very deeply into the brain.

In discussing this subject with the medical officers stationed in St.

Louis in the fall of 1917 and the winter of 1918 for instruction in neurological surgery, I advocated the excision of all traumatized tissue, scalp, dura, and brain tissue and replacing the defect in the dura by a transplanted piece of fascia and closing the skin completely without drainage. During the past year I have had opportunity to apply this method in two cases. The results have been so satisfactory that they seem worth reporting.

CASE I.—J. C. (No. 12,667, Children's Hospital), Milton, Illinois, age, seven and one-half years, admitted April 16, 1918. Discharged May 22, 1918.

April 15th, 1 P.M., was injured while driving a horse. When picked up by a physician he was conscious and crying. Over the right temporal region there was a ragged incised wound from which brain tissue was oozing. Taken three miles to nearest town, and there began to vomit. He became violent at 6 P.M., so that he had to be restrained. No parietic symptoms noted by his doctor. No speech disturbance. Had not voided since accident. Patient admitted to the hospital 9:30 A.M., April 16th. My note on admission was as follows: Boy conscious and rational. Sensorium clear. Lacerated wound, two inches long, over right parietofrontal region. No tremor of either hand. Abdominal reflexes normal. K. K. hyperactive. On the right side, Babinski; a questionable one on the left side. No other evidence of cerebral involvement. Must be treated like contaminated wound. Great danger of meningitis but at end of twenty hours it still may be cleaned out.

Ophthalmological Examination.—Vessels very full and slightly tortuous. Vessels on left side show a blurring of edges. On right side vessels not so full. Fifteen hundred units tetanus antitoxin given.

Operation.—Edges of wound excised. Incision carried back so that skin flap might later be swung over the defect. Stellate fracture. One piece of bone deeply driven in. This piece was removed, and the edges of the exposed bone rongeuired away. Profuse diploic bleeding controlled by wax. Tear in dura 2½ cm. long. Edges contused. Dura opened widely, exposing lacerated pulpy brain tissue. All this area excised down to normal cortex and edges of dura removed. Fascia lata inserted to replace defect in dura. This sewed in with interrupted fine silk. Skin-subcutaneous flap swung over, galea closed with interrupted silk. Silk for the skin. Posteriorly, an area over the intact skull, 1 cm. in diameter, was left to heal by granulation. This was well away from the defect in the skull. Small rubber tissue drain diagonally placed. Drain removed next day. Wound healed uneventfully. Patient discharged May 22, 1918.

November 29th: Patient's physician reports that patient is perfectly well.

CASE II.—I. S. (Sur. No. 6063, Barnes Hospital). Age, fifteen years. Chesterfield, Missouri. Admitted August 21, 1918. Discharged September 15, 1918.

When patient was admitted this history was obtained:

COMPOUND FRACTURES OF THE SKULL

Patient kicked by a mule over left parietal region about two hours before. Large ragged wound of scalp with pulped brain tissue exuding. Skull under this area can be felt to be crushed into numerous small pieces. Patient deeply unconscious; blood-pressure systolic 140. All reflexes abolished with the exception of ankle clonus and Babinski on right foot. Immediate operation undertaken.

Operation.—Vertical incision from zygoma on left side to median line over longitudinal sinus with excision of edges of skin wound. Brain tissue oozing out constantly. Several large bone fragments had been driven into the brain. These were removed. Dura badly lacerated. Edges of dura excised and all the pulped brain excised down to normal brain tissue. A knife used for this purpose. Considerable hemorrhage from a large vein at the bottom of a sulcus. This stopped with a silver clip. A piece of muscle placed over this point. The defect in the dura was closed with a piece of fascia lata which was sewed in place with interrupted silk sutures. Wound dry. Tear in temporal muscle repaired, galea and skin closed with interrupted silk. No drainage. The area of brain removed lay in the precentral area over the face and arm center and encroaching upon the leg center.

Next day, patient began to raise his right arm a little and spoke a few words very incoherently.

Sutures out on the third day. Primary union. Gradual return of power in arm and leg and is beginning to talk a little. Has a partial motor aphasia.

Patient was discharged September 15, 1918. Since then, patient has continued to improve. He has a paresis of his arm and leg but walks about and is using his hand. His speech is improving continually.

The most successful series of gunshot wounds of the brain is reported by Cushing, in Vol. v of the *British Journal of Surgery*. He advocates the use of a rubber catheter attached to a suction apparatus for cleaning out the track of the bullet and removing bone fragments and devitalized brain tissue. In the types of cases here reported such a technic would not seem practical since the area traumatized is a large but comparatively shallow one.

[EDITOR'S NOTE.—The reader will compare with these case reports of Dr. Sachs the practice at La Panne Hospital in Belgium as given by Dr. Janssen, for which see Editorial Comment, p. 61.

A SOURCE OF ERROR IN INTERPRETATION OF RÖNT- GENOGRAMS OF THE SKULL

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IN the November, 1918, number of the ANNALS OF SURGERY, Merrill Miller and E. G. C. Williams of Danville, Illinois, present an article, illustrated with four X-ray plates, entitled "A Radiolucent Shadow Occurring as a Constant Factor in Cases of Severe Intermittent Headache." A study of the article and the four reproductions of plates leads to the belief that the semilunar shadow demonstrated is identical with a like shadow found in a large proportion of all the head plates made in the X-ray Laboratory of the Washington University Medical School. This condition was first noted about June, 1917, and dates from the time when the method of making plates of the skull was changed by the employment of a then new plate-holder. Coincidentally, the clue to the explanation of its occurrence was furnished by these three facts: That it was not observed in plates made by the method previously employed in the laboratory nor in single plates made without using a plate-holder, and that it *was* observed in plates made with the plate-holder to be described later. The shadow has been found in all of the stereoscopic plates which can be described as technically good, in the two hundred and fifty-five (approximately) patients röntgenographed in the laboratory since the date mentioned. These cases cover the range of the various conditions for which röntgenological examination of the skull is considered desirable. In other words, the cases varied from normal to the gross pathological, and the shadow was shown consistently in all types of cases. There was occasionally found also another semilunar shadow, and still others circular in shape, all alike in *quality* to the one described by Miller and Williams.

These shadows have given rise to considerable confusion. Two cases occurring in this city are quite convincing that their incorrect interpretation is fraught with most disastrous possibilities. In one, this dark semilunar shadow was diagnosed as an intracranial hemorrhage, apparently without consideration of the fact that trauma resulting in such an extensive hemorrhage would doubtless have produced symptoms sufficient to have rendered a röntgenogram unnecessary for diagnosis; furthermore, the fact that hemorrhage would produce radiopacity rather than radiolucency was ignored. The shadow in the other case was considered as due to the presence of air in the skull, a more reasonable interpretation on purely röntgenological grounds than the one preceding, but most illogical in the absence of a history of injury sufficient to have caused air

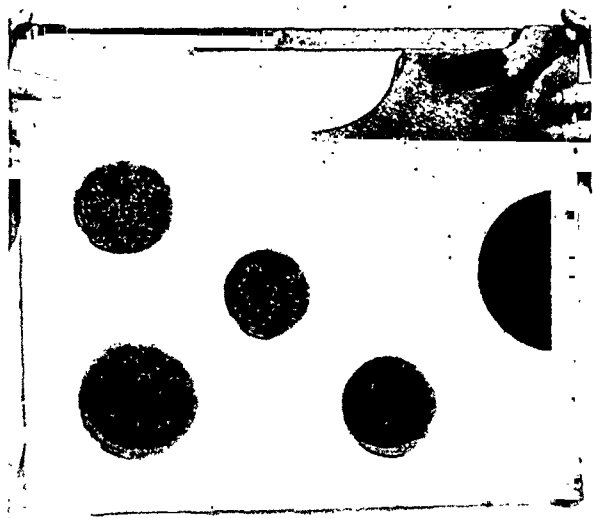


FIG. 1.—Base of cassette.

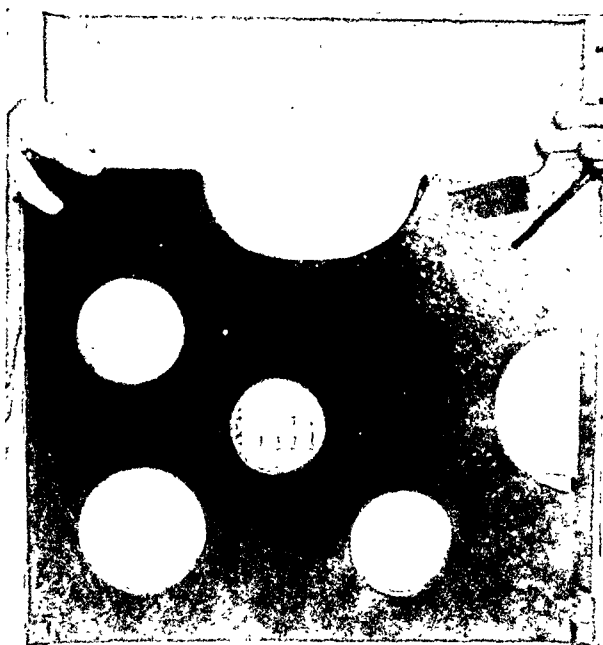


FIG. 2.—Base of cassette, showing plate partially inserted.

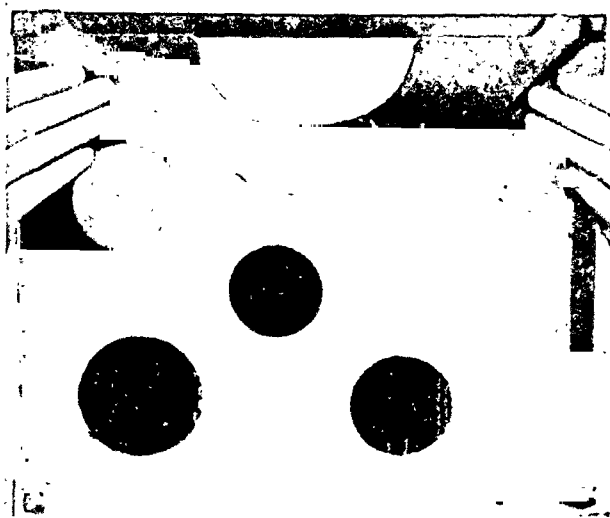


FIG. 3.—Base of cassette, showing X-ray plate in position in cassette.



FIG. 4.—Showing portion of tube, patient and cassette.



FIG. 5.—Showing a semilunar radiolucent shadow.



FIG. 6.—Semilunar shadow absent.

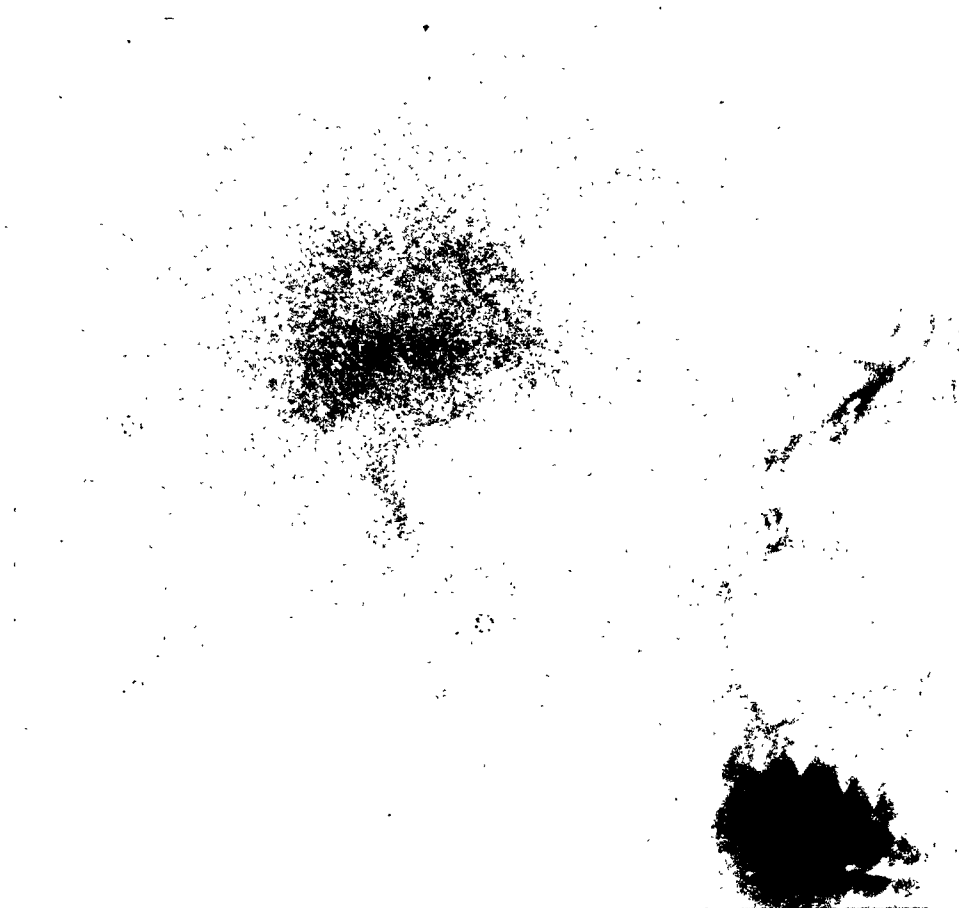


FIG. 7.—Semilunar shadow absent.

to collect in the skull. The possibility of harmful results proceeding from these interpretations of the shadows prompts the reporting of the true cause of their occurrence.

In making röntgenograms of the head, and in all cases where the stereoscopic method is employed, it is necessary that a plate-holder, or cassette, be used in order to secure an unchanging position for the X-ray plates for the two exposures. A widely used, seemingly the only cassette on the market, is one as illustrated in Figs. 1, 2, and 3, which are views of the under side. This under side, or base, of cast iron, has two semilunar areas cut out to facilitate the insertion and removal of plates. There are also three circular areas presumably for decreasing the weight of the cassette. The top is a thin sheet of aluminum tightly stretched. It will be seen at a glance that the cassette can only be conveniently used with the larger of these semilunar spaces located in such fashion that it underlies the vertex of the skull and corresponds in location and curvature to the semilunar translucent areas in the X-ray plates described by Miller and Williams. The outlines of the other deficiencies in the base of the cassette have frequently appeared on the X-ray plates made in this laboratory, but not with the same consistency. Now, were the semilunar shadows shown by Miller and Williams due to an intracranial condition, according to the hypothesis offered by them, namely, the resultant of hydrostatic changes in the cerebrospinal cavity, it would seem reasonable to suppose that the position of the shadows in the X-ray plate of the skull would remain constant in relation to the glabella and inion. However, study of the four plates presented by the writers shows the semilunar shadow shifted anteriorly or posteriorly, as the head was extended or flexed on the neck. This would have been an excellent clue to the explanation of the phenomenon had it been observed. The semilunar shadow in all four of their plates occupies a different position in relation to the coronal plane of the head.

To demonstrate that the findings of the authors are due to the plate-holder employed, the following experiment was made. A healthy subject without history of previous injury, headache, etc., was selected, and röntgenograms made in a manner to be described. Fig. 4, a photograph, shows the position of the patient, cassette, and X-ray tube. Plate made in this position in the usual way, gas tube, focal-plate distance, 24", 60 k.v., 35 m.a., exposure 10 seconds (Niedner timer, Fig. 5), shows the semilunar radiolucent shadow under discussion. A second radiograph was made with a plate of lead inserted in the cassette between the cast iron base and the X-ray plate, all other factors remaining constant. The radiograph shows an entire absence of the shadow in question (Fig. 6). A third radiograph was made without the use of either the cassette or the plate of lead, the X-ray plate resting only on a sheet spread over a wooden block. It will be seen, again, that the semilunar shadow is absent (Fig. 7).

The behavior of the X-ray plate in the cassette in question has been

proven out in this laboratory numbers of times, and there is no doubt that this shadow so frequently seen in head plates is due to the construction of this most commonly used cassette. In short, the semilunar translucent area can be produced at will in a given subject. The makers of this piece of apparatus seem to have ignored a principle almost axiomatic among the older generation of röntgenologists, namely, that radiograms should be made with the X-ray plate supported on a uniform surface, preferably wood. Metals give off secondary characteristic radiations (when exposed to X-rays) and these diminish the clarity of the plate, hence their use as a plate support is to be avoided. Iron produces these secondary radiations in a high degree.

Now, this radiolucent semilunar shadow can be more readily demonstrated as due to the cause set forth than the phenomenon can be explained. Radiolucency naturally comes from an increased reduction of the silver salts in the emulsion on X-ray plates. This reduction, in a limited area, in turn, must be due to the increased amount of rays acting thereon, as compared with the remainder of the plate. The secondary radiations from the cast iron base (iron stands high as a producer of secondary rays) of the cassette acting through the glass of the plate and on the emulsion would naturally lead to the belief that the points at which the plate is supported by the iron would be the darker, which, however, is the reverse of the case; therefore, it would at first appear that either the iron gives off characteristic radiations that neutralize the rays coming from the X-ray tube and the secondary rays arising from the head itself, or, the iron possesses a capacity for absorbing such radiations in greater degree than does air, which is the only substance at the back of the plate where the radiolucent area appears. Nevertheless, this does not explain why the outlines of the small circles in the base of the cassette are not more constantly shown in radiographs of the skull. Considering the phenomenon from all aspects, one is compelled to draw the conclusion that it is extremely complex, depending on the following factors and their interrelations, namely, the action of:

The direct rays from the X-ray tube modified after their passage through the skull;

The "scattered" and characteristic radiations arising from the head;

The "scattered" and characteristic radiations from the aluminum top of the cassette;

The "scattered" and characteristic radiations and coefficient of absorption of the same (arising from the superimposed substances) by the iron base of the cassette;

These same properties in the air at the point where the plate is not supported by the iron base; and finally,

The varying distances (in different planes of the head) traversed by the rays.

However, we are only interested in this question from the practical

röntgenological point of view, and the explanation of why this phenomenon takes place would have to be worked out by the physicist. Suffice that it is proven that the radiolucent semilunar shadow is due to faulty apparatus and is of no clinical significance.

In conclusion, it should be pointed out that structural change in the organism capable of producing radiographic findings as striking as the shadow discussed must rest on a foundation of known pathology. When bizarre and unusual X-ray shadows are encountered one should always consider these two questions:

Can the shadow be due to extraneous causes?

Is there a pathological explanation for its occurrence?

THE SURGICAL TREATMENT OF CANCER OF THE SUPERIOR MAXILLA*

BY WINFIELD SCOTT SCHLEY, M.D.
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THE results of operation for cancer of the upper jaw have not shown a large percentage of cures, judging from collected cases in literature. This is due to several factors—the great malignancy of these growths, especially the squamous-celled carcinoma; the late stage at which so many present themselves, not infrequently owing to wrong early diagnosis; and *very largely* to an incomplete primary operation. Removal of the superior maxilla is an operation still too infrequently done. Its apparently formidable character, with seemingly inevitable disfigurement, causes both surgeon and patient to hesitate. A number of cases are turned down as inoperable which are not especially difficult of operation, and which when operated upon later have given cures over a considerable period of time (five years and three and a half years) and are still apparently well. One such case I am able to show this evening; another (well nearly seven years after the last of two fairly prompt local recurrences) has been heard from recently.

Cancer of the upper jaw, and especially in the maxillary antrum, fortunately remains a *local* disease until comparatively late; nor does it tend to metastasize to the degree of cancer elsewhere. Glands appear under the jaw and in the neck only as a late stage in carcinoma and almost never in sarcoma. The great majority of recurrences are *local*. Glands in the neck in addition to the primary focus in the jaw are not always a contra-indication to operation; and I have seen such cases after a thorough neck dissection from below up, keeping wide of the involvement, remain free of any further neck invasion for three years, and not develop at all subsequently even when local recurrence towards the orbit or pterygoid region occurred. It created a distinct lymphatic block—a matter to be considered in all operations for malignant disease, and especially in that of the mouth and jaws.

The primary operation must be thorough and well beyond the appreciable limits of the disease, as recurrences are often infinitely more difficult, and at times impossible, to deal with; and by delay valuable ground and time are lost. Here, as elsewhere, our results are directly proportionate to the care exercised upon first attack and to extent of field of operation. It is amazing how much can be done (and with so little reaction, as blood loss is small) with external carotid ligation or compression. I have several times actually seen blood loss as little as four ounces, by careful estimate. In upper jaw involvement we do not interfere with the muscles of deglutition as in the removal of the lower jaw, and have not that added source of danger. In the

* Read before the New York Surgical Society, December 11, 1918.

upper jaw as in the lower, carcinoma is more frequent than sarcoma. Giant-celled sarcoma here as elsewhere gives a better prognosis. Two of the cases alive and well to date were of this type, and are here this evening. (One had her first operation of partial resection nearly twelve years ago and has had five very local recurrences.) If the growth is confined to the superior maxilla alone, or with the nares, the problem is greatly simplified. With surface or deep extension towards the soft palate and faucial pillar, or involvement of the orbit or skin of the face, the difficulties are considerably increased; yet this was the condition of the first case of the small series presented, now alive and well nearly seven years after the last of two recurrences of squamous-celled carcinoma. Where the disease has invaded the pterygoid muscles and sphenomaxillary space the condition is hopeless.

The operability of the disease is not always easy to determine. It is not invariably its extent that must determine this point. Its variety, malignancy (so far as determinable), chief situation and apparent and probable direction of extension, and condition of the patient must all be weighed. Within my own experience and my observation of the work of others in this country, patients have always stood the operative work very well—better than one would expect. On the average they can be raised up in bed on the third day and are out of bed on the seventh or eighth. As has been said, glandular involvement in itself, if not extensive, is not a contra-indication to operation.

Preparation for operation is important. Where necessary or advisable the hæmoglobin should be increased and the general condition of the patient should be improved as much as possible during the time it is considered wise to wait. Mouth cleansing, especially with tumors involving the alveolar border, hard palate or buccal mucosa, must be thorough. Good skin cleansing and disinfection of the face insures rapid and accurate primary union of the flap. Preliminary ligation or compression of the external carotid at or above the superior thyroid artery reduces hemorrhage to the minimum. A small dose of morphine and atropine at the beginning of anæsthesia, which is continued through nasal tubes, diminishes the amount of anæsthetic needed and decreases annoying mucous tracheal secretions, while contributing to anæsthesia and seeming to reduce the effect of afferent impulse to the brain. The Ferguson incision—through the mid line of lip, about ala of nose, towards inner canthus of eye and thence out below the orbital margin—gives excellent exposure and command. This incision is a good one for epulis or other benign growths situated far back on the jaw, and with the bony support of the cheek unimpaired; the scar, with careful suturing, is scarcely distinguishable and the functions of the facial muscles are unimpaired. The flap is easily replaced and if the edges are kept clean very rapid primary union takes place. Cutting through bony attachments, the orbital plate should be left if possible to support the eye. The incision through the hard palate and the division from the soft should not be forgotten before avulsion of the bone. It is essential to avoid contamination of skin edges with tumor tissue and to work always outside the limits of the growth and not through

it in removal. The resulting cavity is packed snugly with borated or (better) iodoform gauze in one strip and the end is brought out of the corner of the mouth and secured after suturing the flap. The first packing remains six to seven days. Gauze wrung out of one of the milder antiseptic solutions replaces it at short intervals thereafter. The healing of the cavity is more rapid than would be expected, although with extensive areas several months may elapse before the mouth epithelium has covered the denuded surface.

One of the principal reasons for bringing this subject before you is to accentuate the fact that with good preparation and technic the operative mortality is not large. In recent years, in the hands of all operators, 12 to 13 per cent. European clinics have given 20 to 30 per cent. mortality, largely because the operations have been more extensive than in this country. I believe it is possible to employ Continental thoroughness and still obtain the best American figure heretofore recorded of about 9 per cent. and to considerably better it. The earlier fatalities were largely the result of sepsis and hemorrhage, pneumonia also contributing a large percentage (in one record 72 per cent.) of the deaths. Shock and exhaustion were frequently recorded, probably largely due to hemorrhage. We have controlled sepsis and hemorrhage almost completely, and pneumonia should be no more frequent than after the average operation. Not a few even advanced cases are cured by a thorough operation, if periods of five to nine years can be accepted as proof of cure; and in this domain I think they can, as recurrences when they occur are not long delayed. A very few have returned as late as three years plus several months.

In carcinoma of the upper jaw the neck should be dissected whether glands are palpable or not. In sarcoma, unless glands are palpable, dissection will rarely be necessary although it is a commendable precaution. The neck dissection may be done at a date prior to the removal of the jaw, or at the same time—depending upon the condition of the patient. It should in either case precede the removal of the jaw. In tumors of both upper and lower jaw, palpate the kidney region for possible hypernephroma. I hope to show by the cases presented that the operation is not necessarily even disfiguring, and in some is scarcely detectable in ordinary contact and without prosthetic apparatus. The best two examples could not be present in time for this meeting.

The skin of the cheek, even with well marked bulging from a growth within, seems rarely involved and can be utilized in replacement.

Cases that have been tampered with by local cauterization, electricity and incomplete excision have proved the most malignant. With the antrum, suppurative conditions may mask a coexistent or causative malignancy. A number of these growths appear to start in a nasal or antral polyp, and not infrequently a portion removed for diagnosis does not go deep enough to show the major condition. It is especially suggested to the laryngologist who treats the nose as well, the general practitioner and the dentist to be on the lookout for malignancy in certain recurring polypoid conditions of the nares

CANCER OF THE SUPERIOR MAXILLA

and about the antral orifice and in persistently ulcerated conditions of the mucosa about the teeth.

In a gentleman sent me recently with a diagnosis of extensive polyp formation of the left nares (the pathologist having reported pure polyp) my own specimen taken at a deeper portion showed squamous-celled carcinoma. At operation the entire antrum was shown to be filled with neoplasm and the disease extended up to the ethmoid cells.

Finally, the operation of to-day is not productive of considerable shock, bloodletting or delayed convalescence. Present methods of more comprehensive primary operation offer renewed hope and encouragement in this field of surgery, which has shown some brilliant successes in the past and I am confident will show an increasing number in the future.

OPERATIVE TREATMENT OF HARELIP AND CLEFT PALATE

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CONSULTING SURGEON, GLASGOW HOSPITAL FOR EAB, NOSE AND THROAT; CONSULTING SURGEON, ROYAL HOSPITAL FOR SICK CHILDREN

WITHIN the limits of a single article it is impossible to discuss fully the treatment of these common and distressing deformities. In their cure or alleviation the best results are often attained only by the coöperation of the surgeon and the dentist, and the more severe cases tax the skill of both. In 1912 the British Dental Association did me the honor to invite me to give a demonstration of cases treated by operation, and in doing so I had occasion to comment on some alterations in the views recently held as to treatment. In the course of an operative experience of hundreds of cases, some of whom are now over twenty-five years of age, my own views have undergone considerable change. For what they may be worth these views on certain controversial points may be of service if only by way of stimulating discussion. The last word on some of these points has yet to be spoken.

Date of Operation.—The earlier the better, and this for three reasons: (1) The earlier the age the less the shock. Psychic or mental shock (the result of fear) is entirely absent in early infancy. Physical or corporeal shock (the result of pain) never attains considerable degree in the undeveloped nervous system of the infant. Stick a pin ever so lightly into an adult and he not only winces sharply but pulls away the injured part. Stick a pin into an infant of a few days old and he responds much less quickly and vigorously, and clearly does not locate the pain. His nervous system is not yet acute and educated. All he is apparently conscious of is a vague discomfort. (2) The earlier the age the more pliable and malleable are the tissues, and this malleability is particularly valuable to the operating surgeon in the partially ossified tissues of the maxillæ and premaxillary. (3) In cases of marked cleft palate it is often the case that a child born well-nourished steadily emaciates from starvation owing to the faulty deglutition. Operation for harelip and cleft palate should be undertaken within the first week or two of life. I have frequently operated on the second and third day. In "simple" harelip (soft tissues of lip only), where one operation may be all that is necessary, cure may be completed during the first week of life. In "alveolar" harelip and in harelip complicated by cleft palate, if the earlier of the successive operations necessary in such cases be undertaken during the first week and the others in as speedy succession as possible, cure may be completed within four to twelve weeks of birth.

Order of Steps.—In "alveolar" harelip and in harelip complicated by



FIG. 1.—Tin-foil plating in harelip operations. The lip has been pared, and lip, ala and cheek freed; and the parts are ready for suture. A plate of tin-foil, x, moulded to the bone, has been fixed by two silk-worm sutures, a, and a', which perforate tin plate and alveolar process. (R. B. The coronaries are temporarily controlled by the artery forceps. Pressure forceps and ligatures are seldom necessary in harelip operations.)



FIG. 2.—Tin-foil plating in harelip operations. Operation completed. The dotted line indicates the position of the plate (which is left for four to eight weeks), and bounds an area larger than the mucous-membrane-lined recess left after removal of the plate. A certain amount of reduction by contraction necessarily occurs.



FIG. 3.

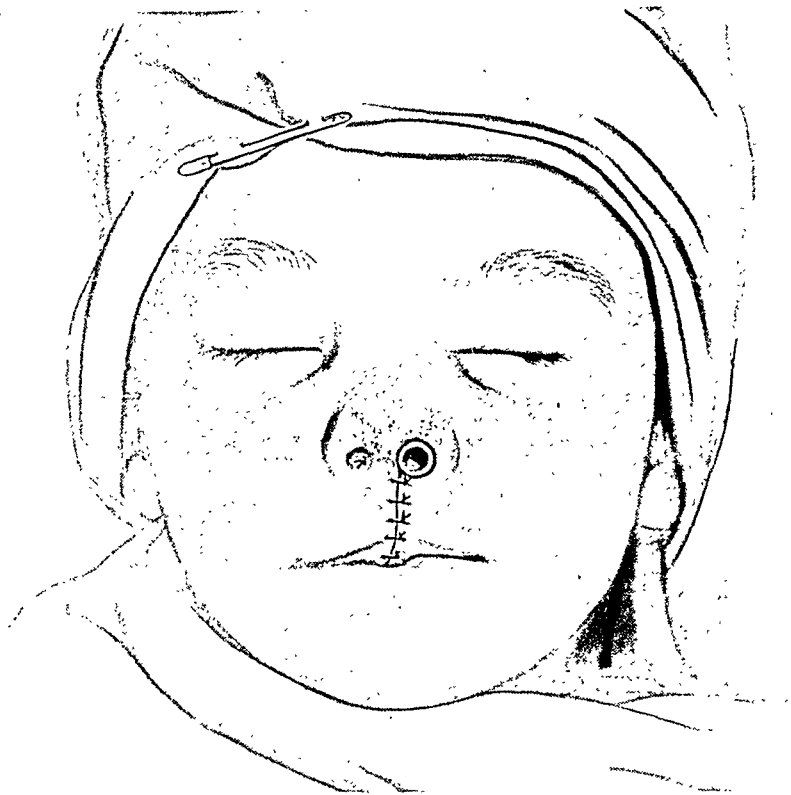


FIG. 4.—Nostril moulding in harelip operations. Nasal splint fixed in position by silkworm suture passed through septum and tied in other nostril (knot shown). In this case a round splint has been used (to match the normal nostril). More often an oval splint is employed fixed with its long diameter antero-posterior. The splint is worn for one to six months. It is seldom earlier than two months after the harelip operation.

OPERATIVE TREATMENT OF HARELIP AND CLEFT PALATE

cleft palate all operations in the way of paring, moulding and wiring the malleable osseous structures should be carried to completion of union before the soft tissues are treated. That should be an unvarying rule even when, as is frequently the case, complete union of the alveolar arch and the hard palate can only be secured by several successive operations. In combined harelip and cleft palate the soft tissues concerned include lip and soft palate. The order in which these should be tackled offers a choice to the surgeon. Operators of limited experience may do well to close the soft palate first, thus taking advantage of the extra room for manipulation and the better illumination afforded by the gaping lip. But those accustomed to operate for cleft palate know that an intact lip (cases of cleft soft palate unaccompanied by harelip are quite common) offers no serious obstacle in operating on the soft palate. To such there is an inducement, after the hard palate has been closed and provided the soft palate has not been dealt with at the same time, to leave the soft palate to the last. That inducement is the increase of blood supply in the velum which follows closure of the hard palate and the lip. One of the chief causes of failure of union in cleft palate operations is the lack of blood supply in the pared and sutured margins, and that lack is more marked in the soft than in the hard palate. The soft tissues covering the hard palate resemble a carpet on a floor; those forming the soft palate resemble a ship's sail, unsupported by any vascular and steadying backing. Closure of the hard palate steadies the soft and increases its blood supply; and, except in these cases in which both hard and soft palates have been closed at one operation, closure of the soft palate may advantageously be made the last of the operative procedures.

Osteoplastic Operations and Flap Operations.—In "alveolar" harelip, especially in those cases in which the premaxillary occupies a projecting, and often also a tilted position, an osteoplastic operation necessarily forms the initial step towards cure. In many cases the soft tissues of the lip cannot be united at all until the intermaxillary has been pared, bent and wired into alignment with the maxillary alveolar arch and its firm union secured there. Further, every experienced operator knows that even in cases where the soft lip can be united over an alveolar gap the result will present a flat nostril or other unsightly features unless the alveolar gap is first remedied by an osteoplastic operation. On these points there is practical unanimity of opinion. Operation on the soft tissues of an alveolar harelip must be preceded by operation on the osseous structures.

It is on the question of the best technic in cases of cleft palate that opinion is divided. One school favors the flap method, the other the osteoplastic. The sliding flaps of Langenbeck and the turnover flaps of Davis Colley and Arbuthnot Lane often give excellent results. But in the hands of less experienced and skilful operators failure is not infrequent. Osteoplastic operation, as finally perfected by Brophy, is an alternative or auxiliary measure which in my experience has proved of the

highest value. It is difficult to understand the disfavor with which it has been regarded. Much of the unfavorable criticism of it seems to arise from misunderstanding. When one reads of "cutting through" the attachments of the maxillæ, and of "fracturing" the maxillæ in order to approximate them, and of "dissecting up" the cheek from the buccal surface in order to place the wires, one cannot wonder at the dangerous reputation of the operation. No such steps are ever necessary in Brophy's operation if undertaken when he advocates it, namely, during the early weeks of infancy. At that date the soft, partially ossified maxillæ can be pushed and bent towards the middle line and fixed there by wires without danger to the patient. In two papers read to the British Medical Association (*Brit. Med. Jour.*, Sept. 18, 1909, and Sept. 27, 1913), on the "Surgery of Infancy and Childhood," dealing with some 20,000 operations in *out-patient* children, I indicated that some hundreds of these were cases of harelip and cleft palate. A number of these were operations including bending and wiring of the maxillæ and intermaxillary by Brophy's and other methods. Osteoplastic operations on the maxillæ of *infants of a few days or weeks old* are *bending or moulding* operations, with little hemorrhage or shock; and many of my cases in the Children's Hospital and the Western Infirmary of Glasgow and in private practice have been operated on and treated throughout as out-patients.

Another criticism of such operations as Brophy's is that the altered position of the maxillary arches produces nasal obstruction and also imperfect alignment of the upper and lower teeth. Nasal obstruction must be rare. I have not met with a case. Imperfect alignment of the teeth, in such cases as it does occur, and these are for the most part those in which extensive alterations in the position of the premaxillary have had to be made, should not be treated by extraction of the irregular teeth, but handed over to the dentist for correction by regulating appliances. Irregularity and lack of alignment concern the incisors and less often the canines. In the molars they are seldom seen. Making use of both flap and osteoplastic methods in combination gives, I believe, the best results in cases of complete cleft palate in association with alveolar harelip, and the surgeon who proposes to deal with such cases should be familiar with the technic of both methods.

Coöperation of Surgeon and Dentist.—In cases of alveolar harelip the patient after operation should be placed under the observation of the dentist. Too often, when the date arrives, faultily erupting teeth, milk or permanent, are ruthlessly extracted. Such extraction not only sacrifices the tooth or teeth, but leads to atrophy and non-development of the portion of the alveolus bearing the empty tooth sockets.

NON-PARASITIC CYSTS OF THE SPLEEN*

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FROM time to time there appear in literature reports of cases in which the spleen has been removed on account of cystic disease. The histological examination of many of these cysts definitely establishes that they are not parasitic in origin and also that they are not the result of error in development, as, for example, dermoid cysts. Only two cases of the latter have ever been reported, that by Andral in 1829 (*"Précis de Pathologie,"* 1829) and that by Kumaris in 1915 (*Archiv f. klin. Chir.*, cvi, 1915). The other non-parasitic cysts are unusual. The number of reported cases, however, is slowly increasing.

Monnier, writing in 1903, could find thirteen cases reported to which he added one removed at operation by Kronlein in Zurich (*Beiträge z. klin. Chir.*, lxi, 1903). Powers collected thirty-two cases and added one of his own (*ANNALS OF SURGERY*, xliii, 1906).

Heinricius collected in 1904 thirty-six cases of cysts of the spleen, seven found at autopsy, nine treated by puncture, two by marsupialization, two by incision and drainage, three by resection of the spleen, and thirteen, including his own case, by splenectomy (*Archiv f. klin. Chir.*, lxxii, 1904). In 1913 Fowler collected eighty-three cases from all sources (*ANNALS OF SURGERY*, lvii, 1913).

The term non-parasitic cysts includes a number of widely different conditions which may be separated into distinct groups. The following classification has been suggested by Fowler:

- (1) Traumatic cysts (hæmatoma). These are large unilocular cysts.
- (2) Infoliation cysts (traumatic or inflammatory inclusions of peritoneum). These are small multiple cysts which may be superficial or deep.
- (3) Dilatation cysts (ectosis of splenic sinuses).
- (4) Disintegration cysts (arising from arterial degeneration and occlusion or other arterial occlusion as from emboli, and resulting in infarction and necrosis of parenchyma).
- (5) Neoplastic cysts (hæmangioma and lymphangioma).
- (6) Degeneration cysts (arising from secondary changes in 5).

The following case substantiates the fact that there is no group of symptoms which can be recognized as characteristic of splenic cysts. The cases present a varied picture referable to neighboring organs and directly due to the great enlargement. It is presented because it brings up the interesting question of the pathogenesis of cysts lined by connective-tissue cells occurring

* Read before the New York Surgical Society, November 13, 1918.

in various parts of the body, as in bones, thyroid gland, omentum, mesentery and elsewhere. The case was referred by Dr. Graef in July, 1918.

C. G., age thirty-four, woman, was admitted to the Presbyterian Hospital July 8, 1918.

Chief Complaint.—Pain in epigastrium, loss of weight and strength.

Family History.—Father died at seventy-three of cancer of the stomach. Mother died at fifty-five from cancer of the mammary gland. One sister died of tuberculosis of the intestines. One sister died of some disease of the breast. Brother was killed in an accident.

Previous History.—She had the diseases of childhood—measles, whooping-cough, chicken-pox. In 1896 when she was twelve years old she had a severe attack of malaria. In 1906, twelve years ago, she was severely injured in an automobile accident. The left side of the body was badly bruised, and she was confined to her bed for three weeks. In 1912 she had a left ovarian cyst and the vermiform appendix removed; following which she was perfectly well until her present illness.

Present Illness.—In May, 1915, she began to have dull pain in the epigastrium while walking. This came on only at odd times. It was not constant at first, nor did it at this time have any relation to the ingestion of food. She had no nausea or vomiting. The pains gradually grew worse and more frequent, and in July, 1915, she began to lose weight, and by January she had lost thirty-six pounds. She also became nauseated during these attacks, but she never vomited. By January the attacks of pain and nausea would always come on shortly after eating, last fifteen or twenty minutes and then cease. They were not relieved by soda, milk, or water, and no particular variety of food seemed to aggravate them. In July, 1916, she began the systematic use of soda, but without relief. In October, 1917, she was placed on a strict Lenhartz gastric-ulcer treatment and spent most of the time in bed until January, 1918. Under this treatment she improved greatly and at the end of this period all her symptoms had disappeared and she had regained her weight and a great deal of strength. She soon returned to the regular routine of her daily life and commenced to eat a simple general diet. After a very short time her old distress and pain returned and became even more severe than before the Lenhartz treatment. She went to Atlantic City for rest and was much improved after two months. Shortly after her return in March, 1918, her distress again recurred and she now had attacks of pain which would last continuously for two or three days, which gradually wore away after abstaining from almost all food. During these periods she had a great deal of gas which she brought up. She had begun to lose weight again and she felt extremely weak.

Physical Examination.—Patient was fairly well nourished, rather pale, anæmic-looking woman who did not appear to be in any great pain. Heart and lungs normal. No glandular swellings felt anywhere. The abdomen was soft, no rigidity and no masses felt. Liver percussed from fourth rib to free border and was not felt. A median scar above symphysis was not tender. There was a tenderness on deep



FIG. 1.—X-ray of stomach after ingestion of barium. Note irregularity of outline characteristic of an extra gastric body pressing against and thus infolding stomach wall.



FIG. 2.—Internal surface of spleen showing large area denuded of peritoneum the site of former adhesion to stomach and diaphragm.



FIG. 3.—Showing the external surface of spleen. Note the two protrusions of the cystic cavity.

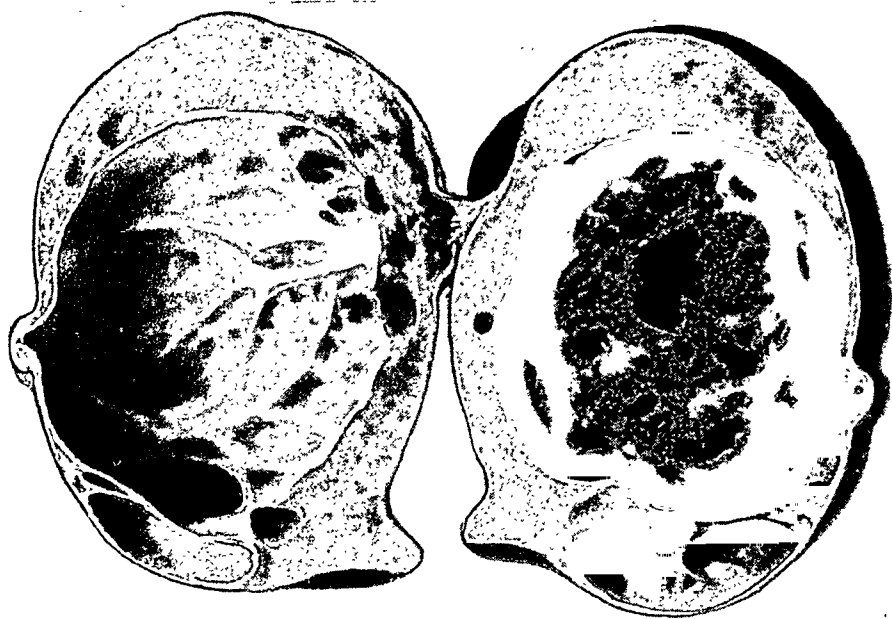


FIG. 4.—Spleen sectioned showing the granular character of cyst contents and the relationship of cyst to capsule of spleen. Note also cavity with the thin membrane-like septa separating the loculi and the ridges on the surface.



FIG. 5.—Low power showing loculi of the cyst and also the free edge of the projecting folds, separating them.

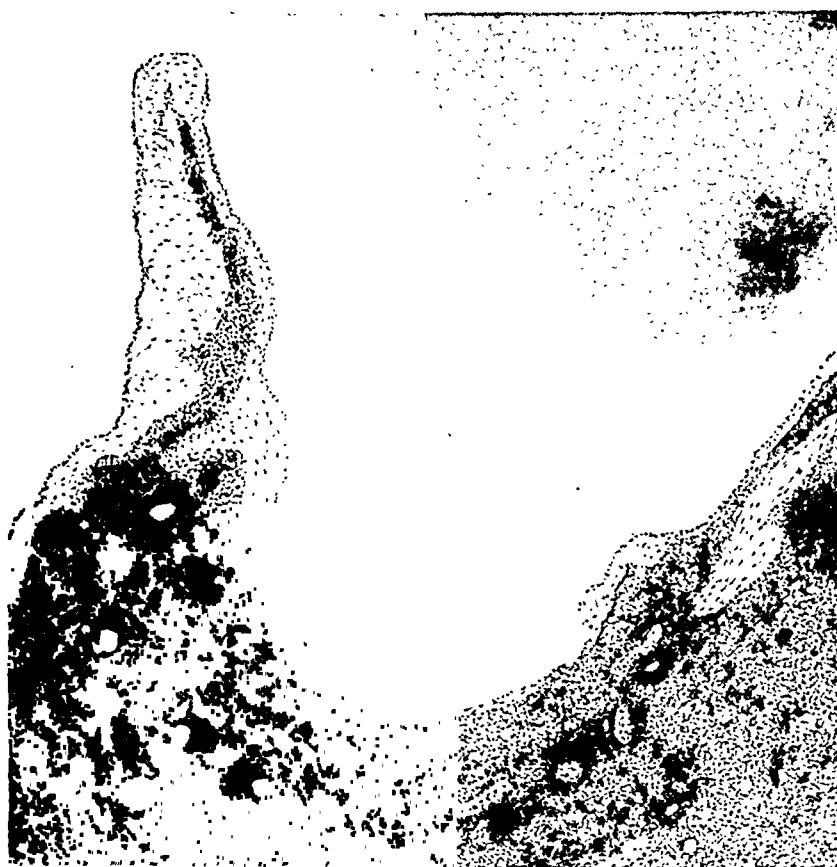


FIG. 6.—Shows the septa projecting in cyst cavity. Note splenic pulp persisting in the septum.



FIG. 7.—Spleen sectioned showing the granular character of cyst contents and the relationship of cyst to capsule of spleen. Note also the multilocular character of cyst cavity with the thin membrane-like septa separating the loculi and the ridges on the surface.

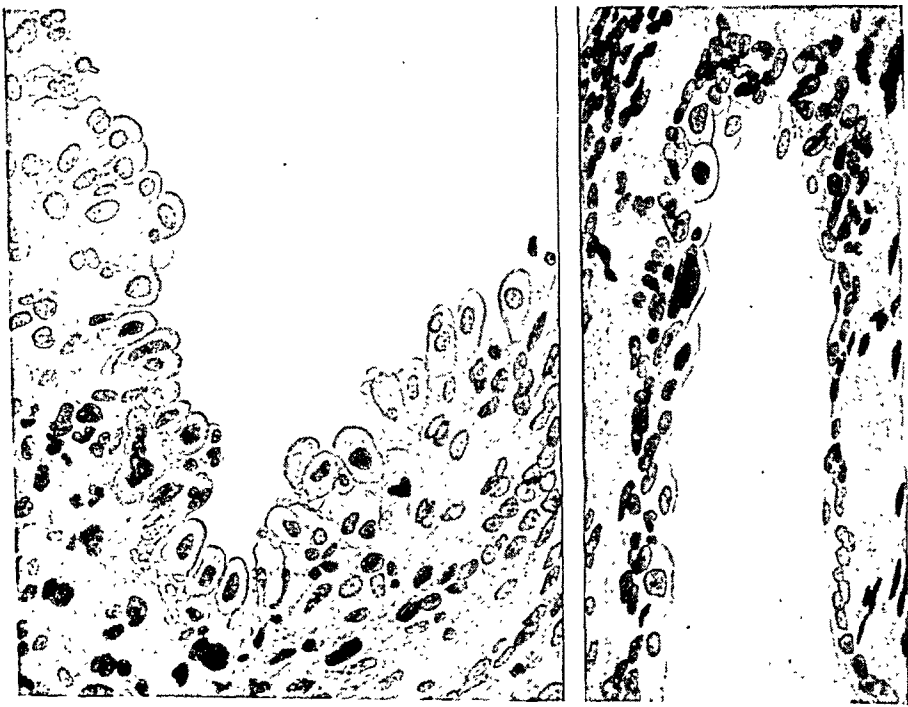


FIG. 8.—Shows the character of the cells lining the cyst. Note the great variety in form and irregular arrangement.

pressure over the left side below free border of the ribs. Spleen not felt.

Gastric analysis showed slight trace of occult blood with Benzidine test. Free HCl 36. Total, 50. Blood examination showed moderate increase in leucocytes. Red blood cells, 3,800,000; hæmoglobin, 78 per cent. Repeated examinations of the stools for blood were negative.

X-ray examination showed the characteristic picture of a change in outline of the stomach dependent on pressure from without—what Carman has described as pseudo-hour-glass stomach (Fig. 1). The pylorus showed no change in outline which could be considered pathological. No fluoroscopic examination was made.

Operation, July 10, 1918.—Splenectomy. A 5-inch median incision above the umbilicus to left of falciform ligament.

The spleen was enlarged greatly in thickness but only slightly in length. It was fixed and firmly adherent to the diaphragm. The pedicle was long and readily ligated. The adhesions were separated with moderate bleeding and the pedicle ligated *en masse* and then divided, the individual vessels being ligated separately. Wound closed without drainage. There were no untoward effects and wound healed per primum.

Blood Examination July 11th, First Day after Operation.—Red blood cells 5,640,000, white blood cells 27,200, polymorphonuclears 80 per cent.

July 13, Third Day after Operation.—Red blood cells, 5,550,000; hæmoglobin, 100 per cent.

July 16, Sixth Day after Operation.—Red blood cells, 5,820,000; hæmoglobin, 90 per cent.

Pathological Report.—The specimen consists of a spleen which is greatly increased in size, chiefly in thickness. There are several areas where the peritoneal cover is wanting (Fig. 2). It measures 9x8x6 cm. On the convex surface there is a white area which is on the summit of the larger of two distinct prominences, which appear as distentions of the capsule at these points (Fig. 3). These prominent areas are elastic and fluctuate. They are evidently the site of cystic cavities. On section these two cavities communicate freely with one another and form one large single cavity, from which there lead out numerous smaller cavities. Its walls are smooth and shining and present numerous ridges on their surface (Fig. 4). These do not form trabeculae passing as bands across the cavity. In many places the septa separating the different loculi of the cystic cavity are reduced to thin transparent folds, having a sharp, free, sickle-like edge, which projects free into the cavity of the cyst (Figs. 5 and 6). In many places there are thickened ridges in the folds. In one place the cyst lining is separated from the surrounding splenic tissue as a thin transparent membrane by what appears to be a recent hemorrhage.

The contents of the cyst was an amber-colored, clear fluid, too thick and glairy to be drawn through a fine hypodermic needle. On fixation, the cyst contents coagulated and had a granular appearance where it had shrunk from the cyst walls. On section it showed whitened areas surrounded by a brownish, grey, mouse-colored granular material (Fig. 7). The cyst wall may be readily stripped from the surrounding splenic pulp as a distinct membrane, and even where it lies directly beneath the capsule of the spleen and in intimate contact with this capsule it is distinct and can be readily separated.

Microscopic Examination.—The wall of the cyst is sharply differentiated from the surrounding splenic tissue. It consists of an envelope of fibrous tissue, which has few nuclei. In many places this capsule is thickened where ridges are found in the wall. Here we find blood-vessels in the wall. It would seem that during the increase in size the cyst had encroached on the surrounding splenic tissue, but the presence of blood-vessels and more resistant tissue here had prevented their disappearance. This fibrous-tissue envelope is covered by modified connective-tissue cells, which form the lining of the cyst. These cells are wanting in many places, having been stripped off with the contents, as this contracted owing to the action of the fixative fluid. Where they remain in situ, they appear as a layer of cells, ellipsoidal in form for the most part (Fig. 8). In many places where the layer is stripped off we see the cells on the flat, and here they have irregular forms, some crowded close together arranged in a mosaic, while in other places the cell bodies are widely separated, with intercellular ground substance appearing between them. The nuclei of these cells stain deeply and the cell bodies also take the stain well. In some places, particularly in a deep recess in the reëntrant angle between the wall proper and a trabecula, the cells have a more cuboidal form, and here there appear to be several layers of them. Sections through the hilum show the presence of an old infarct which is undergoing organization.

There are many explanations of the pathogenesis of these cysts, and from a study of the case reports and histological findings it is evident that we are dealing with a complex and not a simple problem. No single theory appears to explain satisfactorily all the cases. This is not surprising when we consider what varied pathological pictures the different cases present. The patients' age, and sex, and numerous diseased conditions have been invoked as contributory causes. Pregnancy and malaria are the most constantly mentioned factors. No closer or more direct connection can be established than to state the fact that among the cases reported there are more women than men, that many of the patients have had malaria and in a number the first symptom appeared during pregnancy.

On the other hand, traumatism in many instances immediately preceded the occurrence of symptoms and the contents of the cysts in many cases showed evidence of an antecedent hemorrhage (Camus, "Thèse de Paris," 1905). In this discussion I have ignored the examples which are the result of degeneration of neoplasms and also the cases which are represented by lymphangiomata.

Fink¹, Ashoff², and others, consider the latter as the pre-existing conditions in most cases. Undoubtedly this is true of multiple cysts. Other explanations offered are that of Schmidt³ and Ramdohr⁴, who believe that cysts develop from changes in portions of splenic pulp which have prolapsed through rents in the capsule, occurring as a result of splenic enlargement

¹ Prager, Med. Zeitschr. f. Heilkund., vi, 1885.

² Lubarsch und Ostertag Ergebnisse d. Allg. Path., vii, 1900-1.

³ Virchow's Archiv, clxiv, 1901.

⁴ Virchow's Archiv, clxiv, 1901.

from malaria, typhoid or pregnancy. Renggli⁵ considers them due to a snaring off of peritoneal cells, which thus gives rise to inclusion of cysts.

Pilliet⁶ believed they arose from transformations in angiomata. One can readily distinguish in such tumors many cysts which form from hemorrhages occurring in these growths. None of these etiological factors appears to have been the starting point of our present case.

Bötcher⁷ reports a case in which he believes the cyst arose from necrosis of an area of the spleen which resulted from the occlusion of the vessels due to amyloid degeneration. In this connection infarcts of the splenic vessels have been reported as having occurred in connection with these cysts, Bircher⁸ having observed such a case.

In view of the pathological findings I believe that such a condition was responsible for cyst formation in this case, as the presence of old thrombosed vessels would rather confirm this view. The history of trauma twelve years previous must be considered and it is interesting to speculate on how and why a cyst should ever form following a hæmatoma. The study of the morphology of the cells lining such a cavity throws no light on this problem. For these cells do not differ from those covering other connective tissue-lined cavities, such as adventitious bursæ or spaces surrounding non-irritating foreign bodies. They are simply modified connective tissue cells—that is, cells of mesenchymal origin; and when they line cavities containing collections of fluid of long standing, they take on the cuboidal form. It does not appear to matter whether the mesenchymal cells have served as lining to blood or lymphatic vessels, or become the essential covering of the peritoneum; they revert to this type, and are indistinguishable morphologically from those which have never been in their life history differentiated from simple connective tissue.

It seems necessary to invoke some biological factor to explain the continued presence of free fluid within the body. It does not appear probable that the fluid is a true secretion. This would ascribe to these cells a power which we are accustomed to associate with those of a more specialized type. It would seem more probable that it was a question of osmosis or transudation and that there exists a difference in surface tension in the different portions of the bodies of the cells lining the cyst. It is not difficult to conceive that there might be a distinct contrast between the surface tension on the free face of the cell body turned toward the cyst cavity, where it lacks all support from surrounding structures, and that face opposed to the underlying fibrous capsule, bathed as it is by the body fluids exerting a certain degree of

⁵ Inaug. Diss. Zurich, 1894.

⁶ Bull. de Société de biologie, Paris, 1892.

⁷ Dorpster. Med. Zeitschr, i, 1870.

⁸ Deutsche Zeitschr. f. Chir., xcii, 1908.

pressure against it. The slow progressive increase in fluid contents could then be due to that difference in surface tension. There has never been, so far as I can discover, any exhaustive study of the chemical composition of the cyst fluid. Such an investigation might aid us in solving this problem.

At present no satisfactory explanation has been offered to account for these cysts, and the subject offers a profitable field for research.

The symptomatology is largely based on pressure and the increased size of the spleen. Either the condition is recognized on account of the mass of the greatly enlarged spleen, or because of the spleen having displaced other abdominal organs. It is frequent to have gastric disturbances. Vomiting is often present. The majority of cases complain of pain, for the relief of which the patients first consult a physician. There are no symptoms which point to disturbance in the splenic function.

The majority of cases are not associated with dense vascular adhesions and splenectomy has become the treatment of choice by most surgeons.

VARIABILITY OF THE PATHOLOGY AND SYMPTOMS OF CHRONIC INTESTINAL OBSTRUCTION*

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It is not always easy to decide what constitutes chronic intestinal obstruction, but any case that extends over a prolonged period without grave symptoms and not necessitating an immediate operation may be classed in the category of cases of chronic intestinal obstruction. This period of time may be indefinite, extending over weeks, months and even years. The cases of long standing simulate those of the pronounced neurasthenic, but by abdominal section the true pathology is revealed. The character of the symptoms varies with the location and intensity of the pathology. Often extensive pathological conditions give rise to few symptoms.

Pain is the most common symptom, while vomiting, always found in acute intestinal obstruction, is practically absent. Diagnosis is easy when a mass can be felt, but, when one must depend on the subjective symptoms entirely, one is often surprised at the pathology encountered at operation. Some of the various conditions encountered in the author's experience have been a subhepatic collection with duodenal adhesions, an enterolith with adhesions to the ileum and appendix, slowly forming volvulus, purpura hæmorrhagica intestinalis. The operations performed in these cases will be described. There was no mortality in this series.

CASE I.—*Subhepatic collection with gastric, duodenal and colonic adhesions.* The patient was a woman thirty-five years old. She had been sick six weeks before I was called in consultation by Dr. William E. Raken. Upon examination a large mass was felt in the right hypochondriac region. This mass was continuous with the liver with dulness above extending about four inches below the costal border. At operation a large amount of fluid was obtained in the subhepatic region. The exact source of this fluid was never fully determined. The fluid might have been derived from a ruptured duodenal ulcer, a perforated gall-bladder or an hematogenous infection. Adhesions were noted involving the stomach, duodenum and hepatic flexure. Operation never fully relieved the patient of her symptoms, which were due to the adhesions of the viscera to the abdominal wall and to each other. The sole subjective symptom of obstruction was continuous pain, nausea, but no vomiting. The pulse was gradually increasing in rate. The symptoms of intestinal obstruction were present at the first operation but were not recognized on account of the large volume of fluid being considered the causal factor.

* Read before the Northern Medical Association, April 12, 1918.

The second operation was performed two weeks after the first. A new incision was made in the median line from the ensiform cartilage to the umbilicus. The transverse and descending colons were found collapsed; the ileum was distended. An anastomosis was made between the transverse colon and a portion of ileum. The original incision in the right hypochondriac region and the underlying adhesions were totally disregarded. This is an important point in many cases of intestinal obstruction, namely, to disregard the pathology altogether, not to disturb dense adhesions, but instead to make an anastomosis between healthy viscera.

CASE II.—*An enterolith with adhesions to the ileum and appendix.* Admitted to the Jewish Hospital September 27, 1917. This was a case of considerable interest. It occurred in a woman twenty-seven years old. She had the typical symptoms often found in cases of chronic intestinal obstruction due to an enterolith. She complained of general vague pains (hypochondriacal in character), constipation, nausea and especially pain in the epigastric and right iliac regions. There was no vomiting. She lost considerable weight, a fact which has been noted by others who have reported cases of this character. The only point of interest in the previous history is the fact that in January, 1917, she was operated upon at the Samaritan Hospital, when a dilatation and curettage and a perineorrhaphy were performed. After the operation it was thought that she would not recover on account of the tremendous distention of the abdomen. No doubt the conditions that we found at operation were present at this time, and may be considered the cause of the abdominal distress. Physical examination revealed an ill-nourished woman, anæmic and poorly developed. Palpation of the abdomen elicited tenderness in the right iliac fossa, but no mass could be felt.

The operation was performed under nitrous oxide gas and oxygen. The abdomen was opened through a right rectus incision. The serous lining of the terminal portion of the ileum was covered with numerous white tubercles strongly suggesting tuberculosis. The appendix was located and found considerably enlarged, teased out, adherent to the ileum and containing in common with the ileum the large enterolith shown in Fig. 4. A communication existed between the appendix and the two approximated loops of intestine, constituting by nature's process an entero-enterostomy and an appendico-enterostomy. Upon attempting to separate the adherent portions of the ileum from the appendix the former was torn in several places, necessitating a resection of twenty inches of ileum. The open ends of the ileum were closed and a lateral anastomosis was performed. The abdomen was closed with drainage. In this instance we are unable at this time to decide whether the enterolith had its origin in the appendix or the ileum.

Cases of enterolith of the gastro-intestinal tract have been reported by Alexander, F. P. Henry, Malcolm McLane, W. L. Moores, Marshall, Ward and others. According to Phillips, cases of enterolith are comparatively rare in the human being, but found quite often in

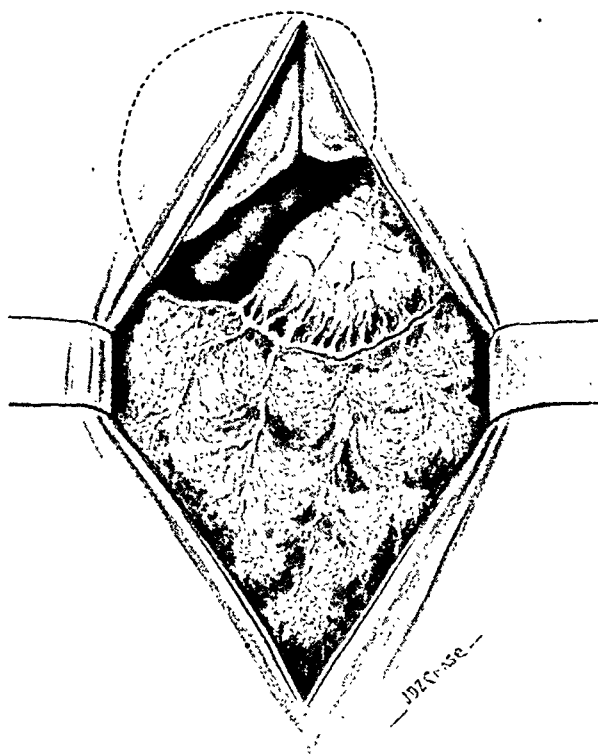


FIG. 1.—Case I, showing subhepatic collection.

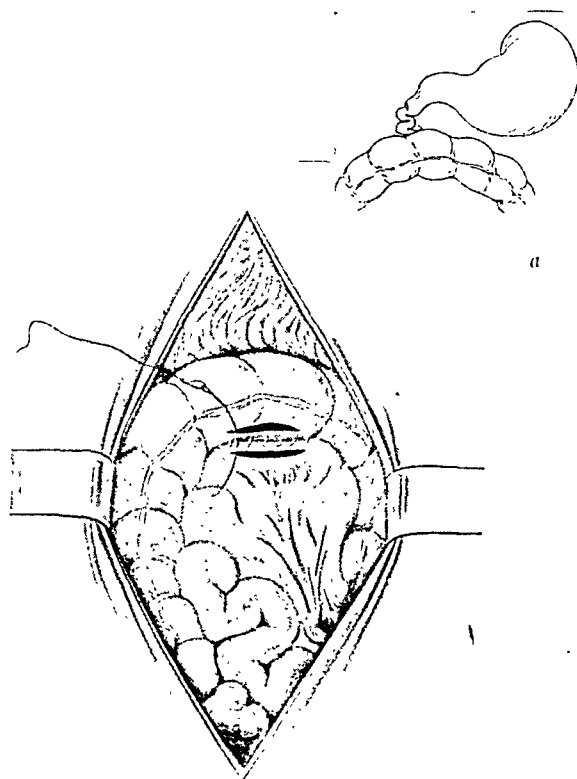


FIG. 2.—Case I. Anastomosis of transverse colon to ileum on account of adhesions around duodenum as shown in *a*.

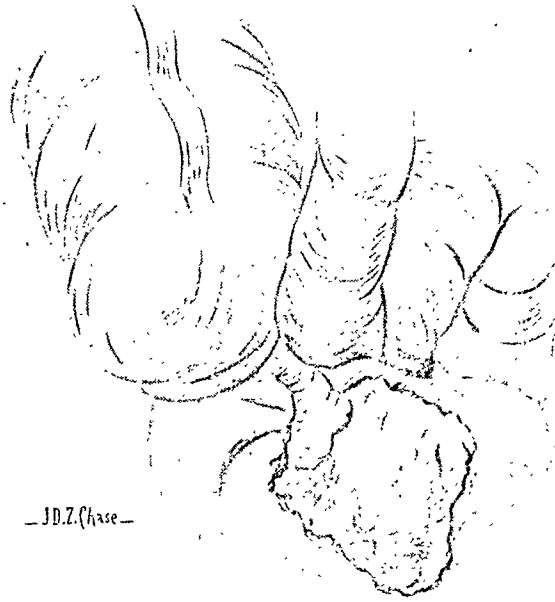


FIG. 3.—Case II, showing enterolith in ileum covered by frayed-out appendix.

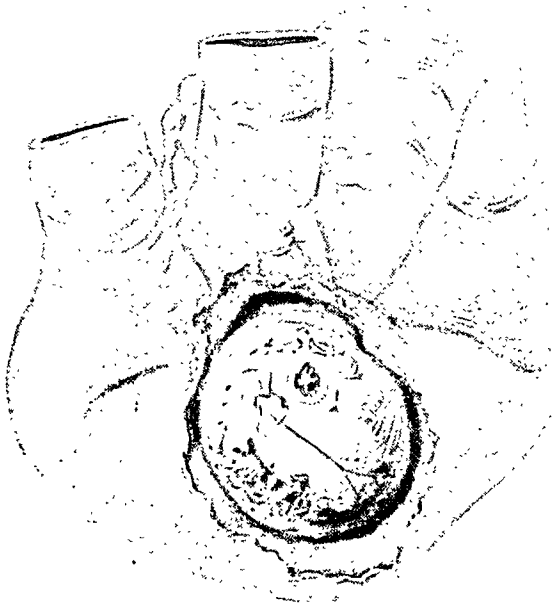


FIG. 4.—Case II, showing enterolith with resected ileum. Appendix removed.

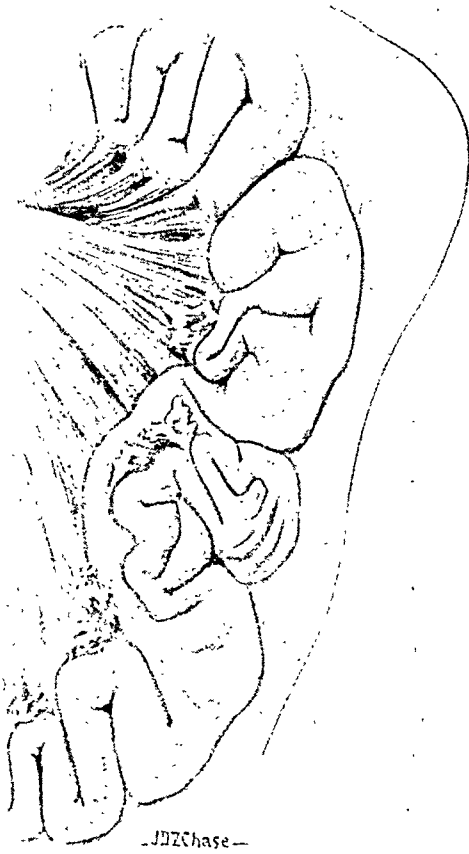


FIG. 5.—Case III, showing slowly forming
volvulus.

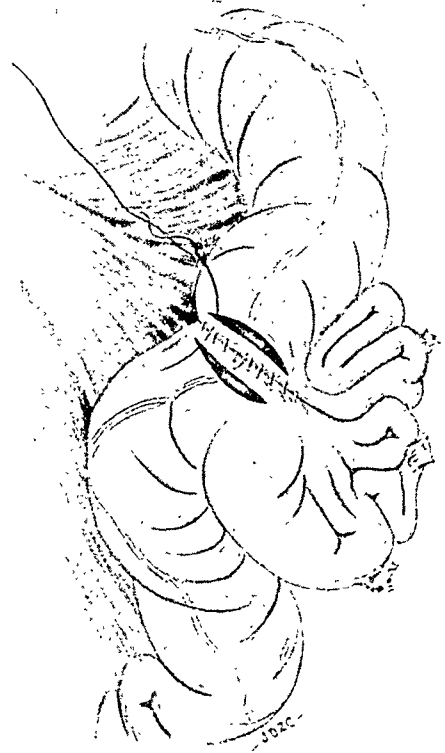


FIG. 6.—Case III, showing anastomosis of sigmoid
to descending colon. Volvulus not removed.

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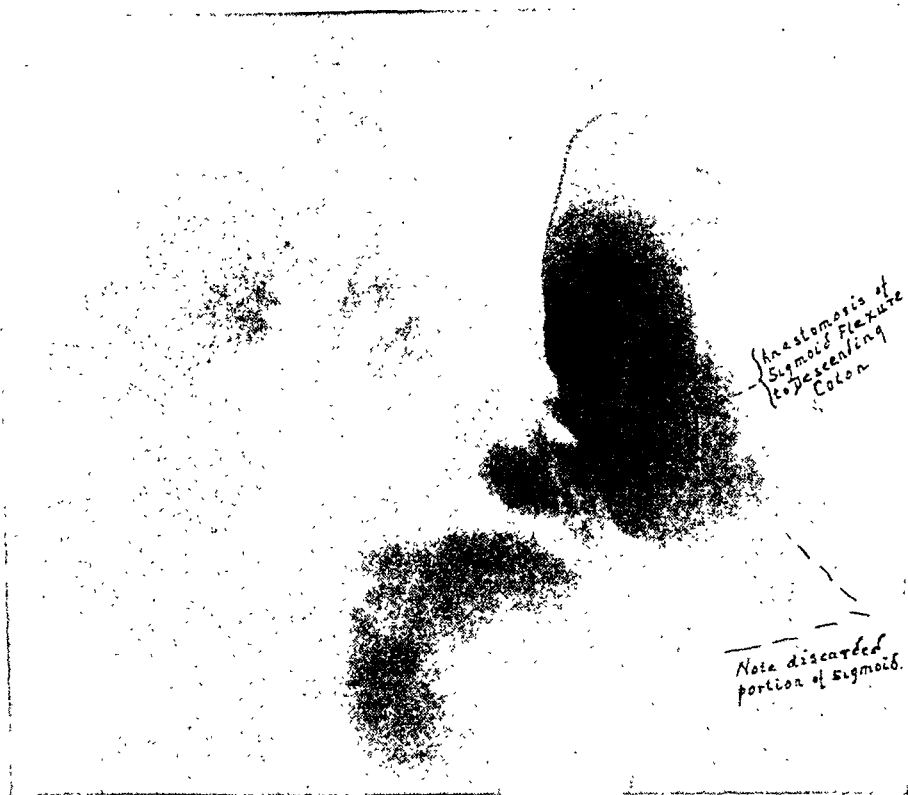


FIG. 7.—Case III, showing anastomosis as result of operation five months before.

the lower animals. Enteroliths usually occur in the cæcum, but when found in the ileum are seen most frequently in the lower part of the ileum.

CASE III.—*Slowly forming volvulus*. This case was of unusual interest on account of the manner in which the symptoms appeared in the presence of a serious pathological condition. The symptoms came on rather stealthily in a woman enjoying previous good health. About six weeks before I saw her, in consultation with Dr. I. Valentine Levi, she noticed that her bowel movements were not as free as usual, in fact constipation appeared with some pain in the abdomen. Her bowels moved but rather ineffectually. Physics and enemas were not very effectual. She did not vomit; there was no nausea. The patient looked comfortable, in fact she refused to go to the hospital because she did not feel sick enough. A diagnosis of intestinal obstruction was made on account of the unproductive bowel movements. She was operated on at the Jewish Hospital November 22, 1917. We found an invagination of the sigmoid with adhesions and several twists in the gut (Fig. 6). In this instance the mass was again disregarded; instead of removing it the distal portion of the sigmoid was brought up to the descending colon where a lateral anastomosis was performed. Fig. 7 illustrates the anastomosis performing its function perfectly five months after operation. After a rather stormy convalescence the patient made a fine recovery.

CASE IV.—*Purpura hæmorrhagica intestinalis*. Admitted to the Jewish Hospital April 8, 1917. The patient was a male, aged thirty-three years, complained of severe abdominal pain and constipation. He was seen, in consultation with Dr. S. Solis-Cohen, in the Medical Wards. Before admission to the hospital the patient was unable to have a bowel movement to which he attributed his symptoms. Since the onset of his constipation he complained of pain in the epigastric region which he described as dull aching in character. Pain was present constantly, but it never localized itself. Four days prior to admission he vomited four or five times a day and had vomited several times a day since admission. He soon developed pain in both knees followed by swelling, later the wrist joints became swollen and painful. A closer inspection of the abdomen elicited liver dulness extending from the sixth interspace to a point somewhat below the costal border. The abdomen was very tender, tenderness being greater in the right upper quadrant than in any other region. Posteriorly there was a petechial eruption hemorrhagic in character.

At operation the gall-bladder was found filled with dark, viscid bile. This was drained, the bile flowing with difficulty through the cannula. A cholecystostomy was performed. The appendix was removed through another incision. Here an excess of peritoneal fluid was noted, and in trying to determine the cause of the presence of so much fluid, it was found that the small intestine from the jejunum to the ileum, and including the ileum covering, in all about eight feet of gut, there were found telangiectatic tumors circumscribing the entire lumen of the intestine. The most advanced and the most obstructive character of

these growths were nearest the jejunum. As the ileum was reached the tumors became less firm and the hemorrhagic spots covered less of the circumference on the bowel. No resection of the intestine was performed because the lesions covered such a large area and on account of their progressive character it was impossible to tell where these hemorrhagic areas would stop.

A review of the previous histories illustrates the diversity of intra-abdominal conditions causing chronic intestinal obstruction.

Case I shows the proper procedure when extensive adhesions around the duodenum, colon and stomach are encountered, namely, to disregard the pathology and make your anastomosis in a healthy area through a separate incision. Case III also shows that wherever it is hazardous to remove the lesion it is better to ignore the cause and make the anastomosis around the seat of trouble. This is a preferable procedure in this region, when it can be done, on account of the comparatively poor blood supply of the sigmoid flexure in relation to the rest of the intestinal tract.

Case IV illustrates one of the rarest conditions causing symptoms of chronic intestinal obstruction. A diagnosis of cholecystitis was made on account of the greatest tenderness being in the right hypochondriac region. Gall-bladder disease was actually present on account of the black gummy bile which flowed with great difficulty through the cannula. Upon making a separate incision to remove the appendix an excess of intraperitoneal fluid was noted. This led to the discovery of the hemorrhagic masses extending from the jejunum and including the ileum.

Case II was the only one in which a resection of the intestine was necessary.

Finally, in all the cases pain was a constant symptom, not always, however, specific in character as to the location of the lesions. Vomiting, a constant symptom in acute intestinal obstruction, was present only to a considerable degree in Case IV. The other cases vomited rarely or not at all. The pulses of all the patients were not rapid. Another striking feature was the absence of toxæmia in these cases, so commonly found in acute cases. All the patients reported recovered and are still enjoying good health, whereas in acute intestinal obstruction the mortality is 50 to 60 per cent.

RESECTION OF THE CÆCUM AND ASCENDING COLON*

By J. SHELTON HORSLEY, M.D.

OF RICHMOND, VA.

THE principles that underlie an operation are more interesting than the mechanical details of the technic. The influence of certain physiological and pathological laws in causing the abandonment of lateral intestinal anastomosis and the gradual adoption of the end-to-end method is particularly striking. When surgeons began to use the needle and thread for uniting intestine instead of mechanical appliances, lateral anastomosis was much in vogue. Fifteen years ago when this transition was occurring, probably the majority of all intestinal resections was followed by lateral anastomosis, particularly if the colon was involved. At present the opposite is true, and even in the large bowel the end-to-end or axial union is becoming popular. Two recent papers, one by Lockhart-Mummery (*Surg., Gyn. and Obstet.*, February, 1917, p. 247) and the other by Donald C. Balfour (*Trans. Southern Surg. Association*, vol. xxx, p. 343), have strongly advocated this method in colonic surgery.

Senn and Reichel called attention to the interference with peristalsis at the site of lateral anastomosis. Cannon and Murphy (*ANNALS OF SURGERY*, vol. xliii, p. 512), after röntgen ray examination of animals in which end-to-end and lateral intestinal union had been done, found that there was not the "slightest evidence of stasis of food in the region of operation" with an end-to-end method. On the other hand, peristalsis was apparently abolished in the region of a lateral anastomosis, the fecal contents being pushed through the anastomosis only when a column of it extended into the unaffected proximal (oral) loop of bowel where peristalsis was unimpaired.

The reasons for this are that the opening is not in the axis of the bowel, the severed circular fibres cannot act upon the bowel contents satisfactorily, and there are two blind pouches in which the fæces tend to collect. The proximal (oral) intestinal pouch is emptied with great difficulty. I have seen a dog die as a result of a small piece of bone lodging in this pouch and ulcerating through.

Lateral anastomosis is made in the direction of the long muscle of the bowel, and these external longitudinal fibres are split instead of being cut across as in the end-to-end method. Contraction of these fibres tends to close the opening in the bowel and a very long lateral anastomosis has to be made to prevent too much contraction.

There is more suturing to be done in lateral anastomosis. The two

* Read before the Southern Surgical Association, December 19, 1918.

ends of the bowel have to be closed, then two openings made into the bowel and the wounds sewed together.

As a final objection to lateral anastomosis, it requires much more bowel to make a lateral than an end-to-end union. In the small intestine this is of no great consequence, but in the colon it may be very serious, as shown by Lockhart-Mummery, and may result in resection of too small an amount.

The objection that has been urged to the end-to-end method has been the fact that it would leak at the mesenteric border. As pointed out in previous communications, in which a new method of intestinal union was described (*ANNALS OF SURGERY*, vol. xxxviii, p. 747; *Trans. Southern Surg. Association*, vol. xxi, p. 198; *Southern Medical Journal*, vol. viii, p. 298; "Surgery of Blood-Vessels," J. Shelton Horsley, M.D., pub. C. V. Mosby Co., 1915, p. 204), the triangular space where the mesentery splits to envelop the bowel has been considered a bad place. This is because the operator by cutting into this space with the same scissors or knife that divides the mucosa of the intestine infects this triangular space, which is rich in lymphatics and blood-vessels, and the infection causes the sutures to give way. It can be avoided by dividing, clamping, and tying this space and by clamping and tying the mesentery before opening the bowel (Fig. 1).

The question of infection in an intestinal wound and the nutrition of the wound are closely allied. If the infection is slight and the nutrition good, the infection may be overcome. It is important to do away with infection as much as possible, and it is also important to have a good blood supply, but to cut the bowel too obliquely to obtain this blood supply may interfere with peristalsis. Disinfecting the intestinal ends before suturing should always be done, particularly in suturing the colon. It may be impossible to sterilize the mucosa just as it is impossible to sterilize the skin by any known method which does not destroy the skin, but certainly the majority of the bacteria can be removed and then the needle and thread will not carry the infection they would if the fecal matter was simply squeezed out and no further effort made to clean the bowel end. Those cases of leakage opposite the mesenteric border in end-to-end union of the colon that some operators have noticed may be due to lack of cleaning the bowel ends with antiseptic solution and so preventing a mild infection where nutrition is weakest.

Kellogg (*Surg., Gyn. and Obstet.*, vol. xvii, p. 563) has pointed out the advisability of reproducing a valve like the ileocaecal valve when the small intestine is united to the large. It has been the common experience that when a union is made without a provision of this kind the small bowel dilates or thickens. This is probably due partly to infection from the colon and partly to the back pressure of the gas in the large intestine. While, of course, such a valve cannot prevent the entrance of a small amount of bacterial flora from the colon, it may act as an ileocaecal valve and protect the small bowel from an overwhelming amount of colonic fecal matter

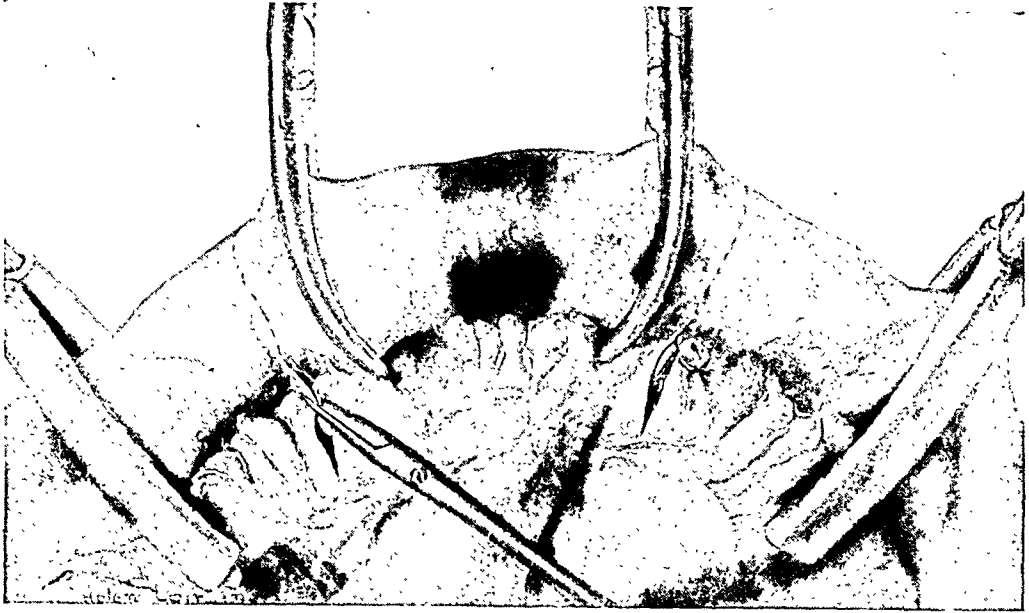


FIG. 1.—Before the bowel is divided its mesentery is cut close to the bowel wall and the triangular space caused by separation of the layers of the mesentery just before they cover the bowel, is clamped with a hæmostat and ligated with silk or linen. This area is composed of areolar tissue rich in blood-vessels and lymphatics which absorb quickly, and, even though it is closed after it has been inoculated, the germs are merely sealed in and are likely to cause breaking down of the union at this point later on. The procedure indicated here obviates this and also brings together the peritoneum at this point.

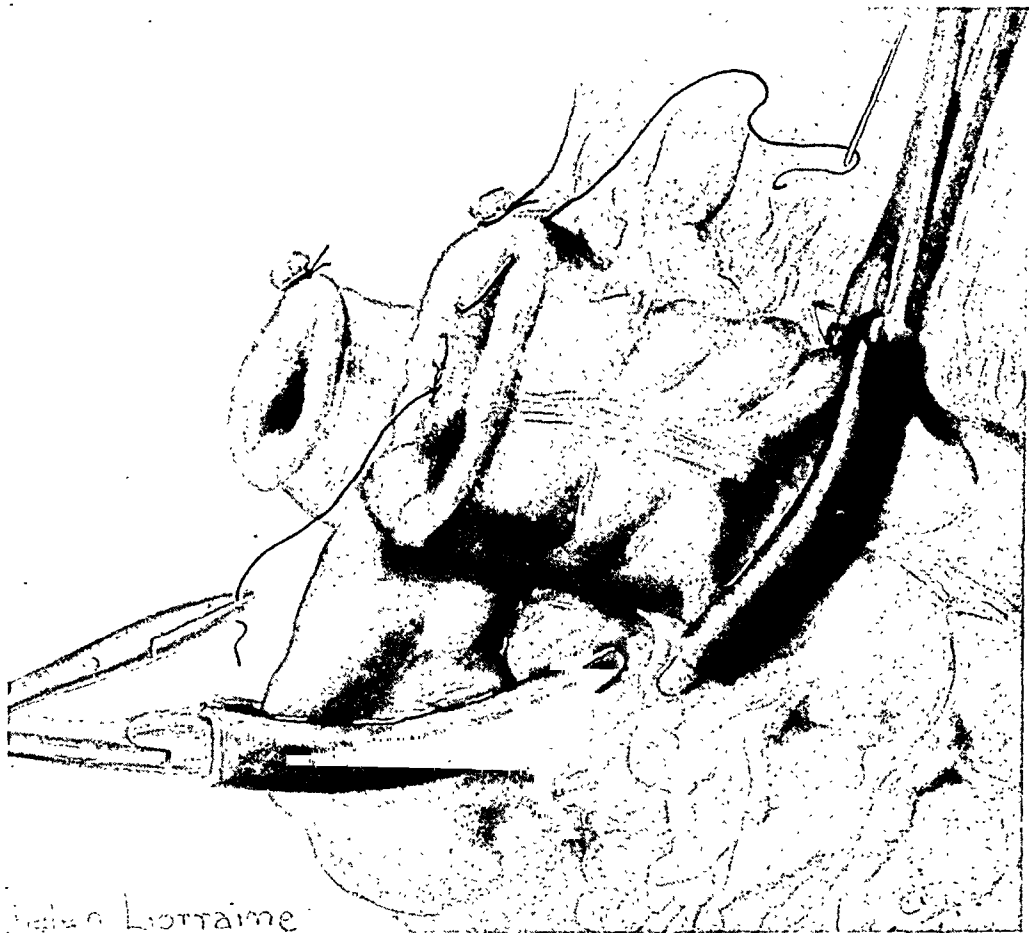


FIG. 2.—The bowel ends have been cleaned with sponges dipped in antiseptic solution and the suturing has begun. A straight needle and linen thread is used, and, starting on the mucosa of the colon, the needle is carried through the colon to the ileum, pierces the ileum about an inch from its end, and returns in a reverse direction. The thread is tied, making a mattress stitch, and the short end of the thread is clamped with a hæmostat. The suture is continued as a continuous mattress stitch.



FIG. 3.—After the mesenteric border has been passed, the needle is brought on to the surface by thrusting it through the colon and suturing is continued as a right-angle stitch, penetrating all coats of the intestine, uniting the edge of the colon to the ileum about an inch from its end, and taking more of the colon than the ileum in each bite. About every third stitch a back stitch is taken to prevent the stitches from being drawn too tight. It is finished by tying to the original short end that was left clamped. *a* shows section of the bowel after completion of the operation and insertion of interrupted catgut mattress stitches.

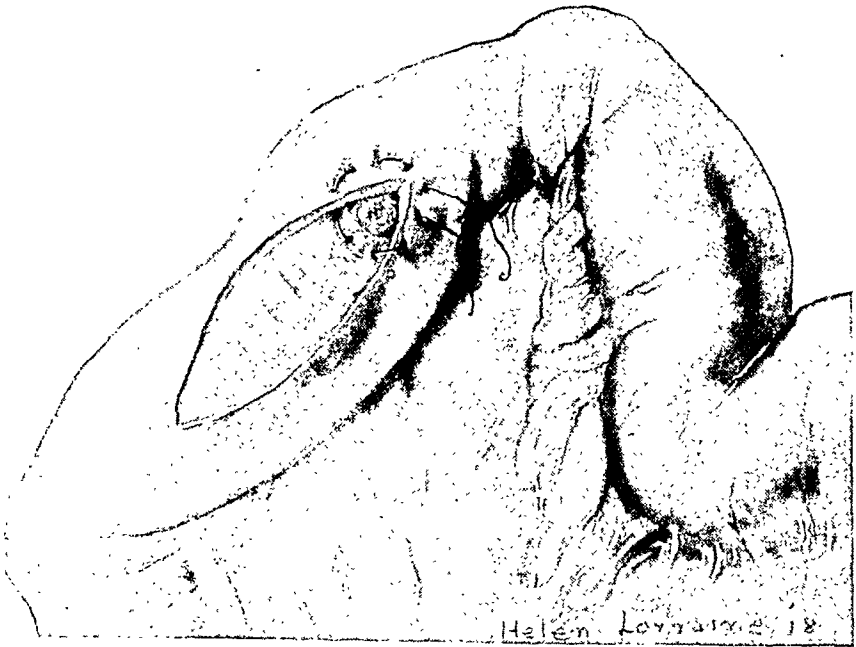


FIG. 4.—In an enterostomy the incision is made through the peritoneal and muscular coats down to the submucosa. At one end of the incision a purse-string suture is inserted.

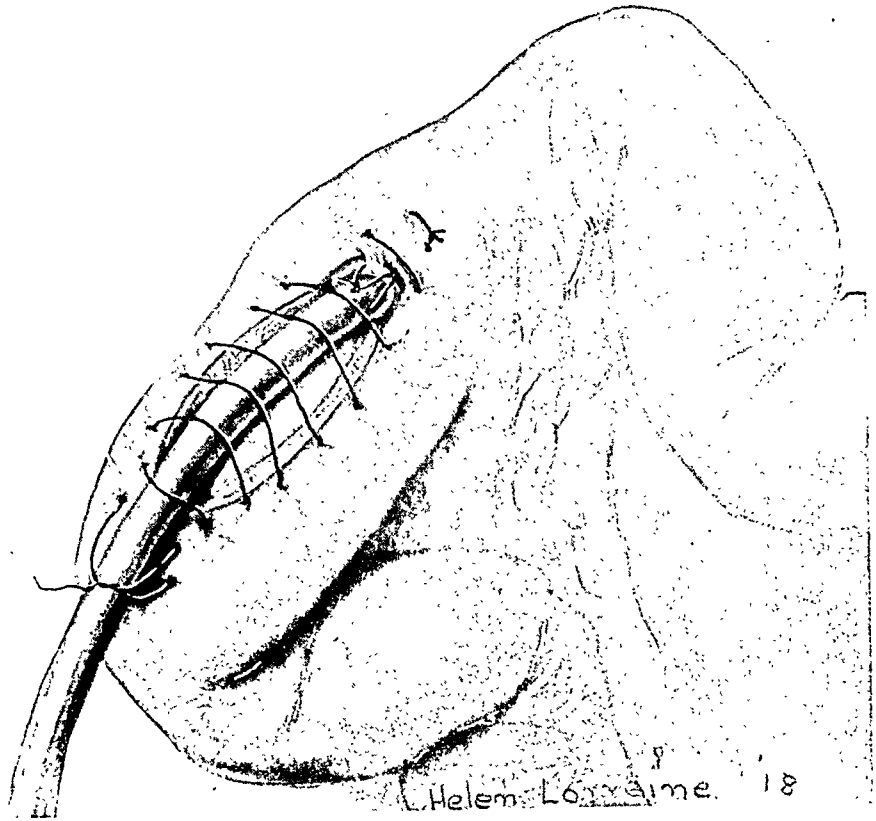


FIG. 5.—The mucosa within the grasp of the purse-string suture is punctured and a catheter is quickly inserted, the purse-string suture being tied snugly about the catheter. One end of the purse-string suture is threaded in a sharp needle and fixes the catheter in position. The portion of the catheter that lies on the incision is buried by a right-angle stitch.

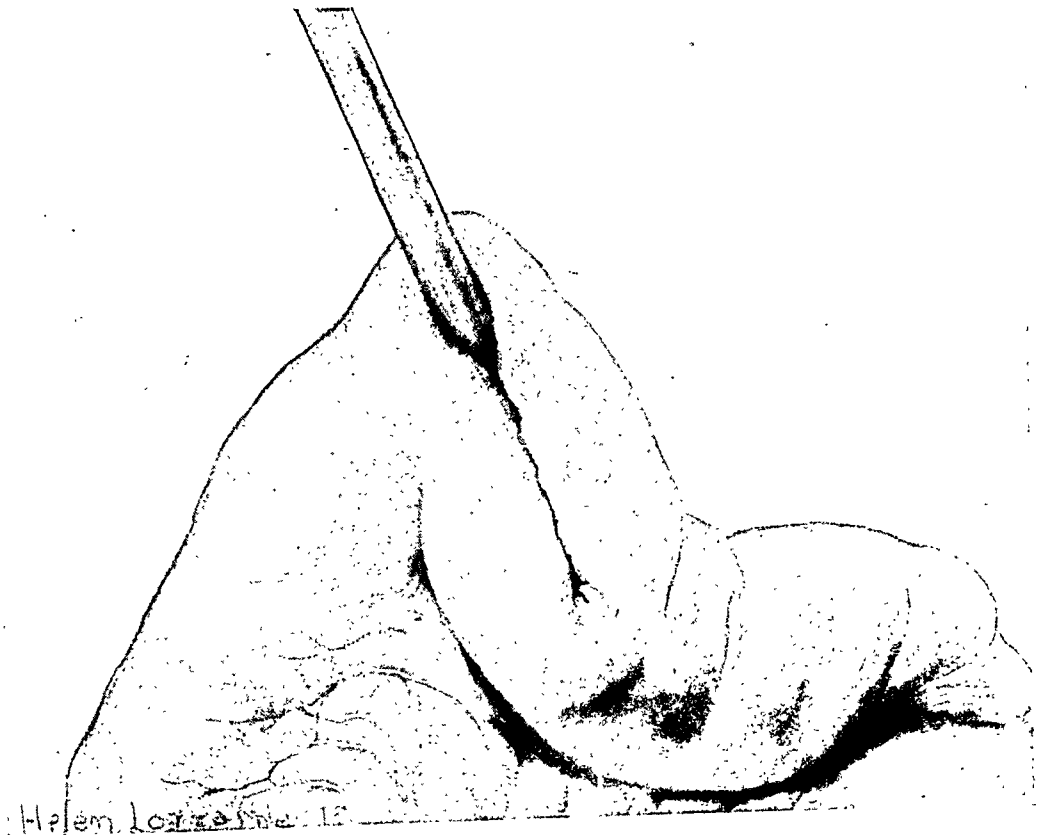


FIG. 6.—The enterostomy has been completed. Usually there is no leaking of the fecal matter when the catheter is withdrawn, due to the valve formation of the mucosa (Coffey).

RESECTION OF THE CÆCUM AND ASCENDING COLON

which would otherwise flood the small bowel with each retrograde peristaltic wave.

The operation here described was developed as a result of experimental and clinical experience and is based upon the principles that have just been discussed. The steps of the operation are:

1. A thorough mobilization of the cæcum, ascending colon, and the lower part of the ileum by dividing the peritoneum to the outer side of the mesentery of the cæcum and ascending colon.

2. Division of the mesentery which supplies the segment of bowel to be removed, taking care to keep as close to the bowel as the indication for the operation permits. The triangular surface at the mesenteric border of the bowel is clamped and tied and all of the mesenteric vessels are clamped and tied (Fig. 1).

3. The bowel which is to be resected is packed off by gauze wrung out of hot saline solution. Wet gauze should be carried under the loop as well as around the ends where the section is to be made. Then the diseased segment is clamped as close as possible to the point where it is to be cut, and intestinal clamps are placed at a sufficient distance from this point on the healthy bowel so as not to interfere with suturing.

4. The bowel is divided with scissors, cutting somewhat obliquely to obtain better nutrition and from the mesenteric border outward.

5. The edges of the mucosa of the healthy end of the bowel are caught at three or four places with small forceps and the end of the bowel from the clamp to the cut surface is thoroughly cleaned with gauze sponges dipped in bichloride solution. After being cleaned of all fecal matter, the excess of bichloride is mopped out and the end of the bowel is covered with a gauze pad wet in saline solution. Then the other end of the diseased loop of bowel is cut off and a similar procedure is gone through with.

6. Suturing is begun, using a straight needle and linen thread, and beginning on the mucosa of the colon. The needle is carried through the colon to the ileum and pierces the ileum about an inch from its end. The needle pierces the ileum from without inward and returns in a reverse direction through the ileum and colon. The thread is tied on the mucosa of the colon, making a mattress stitch. The short end of the thread is clamped with a hæmostat (Fig. 2).

7. The suture is continued by carrying it back and forth after the manner of a continuous mattress stitch, taking more of the colon than of the ileum in each bite of the stitch and keeping an inch behind the end of the ileum.

8. After the mesenteric border has been passed, the stitch is brought on to the surface by thrusting the needle through the colon and is then continued as a right-angle stitch, penetrating all coats of the intestine, uniting the edge of the colon to the ileum an inch from its end, and taking more of the colon than the ileum in each bite. About every third stitch a back stitch is taken to prevent drawing the suture too tight. When the

suturing has reached the point where it began, it is carried on the ileum one stitch beyond the short end of the thread, which was left clamped, and is then tied to the short end. The knot is tied in the line of the incision so it will sink well into the bowel. It is tied three times and cut short (Fig. 3).

9. A row of interrupted mattress stitches of fine tanned catgut is placed around the whole line of sutures. This is done to promote the valve formation and to add to the safety at the point of union. The mesentery is sutured together loosely, and a piece of omentum, if it is in the neighborhood, is fastened over the line of union.

In resection of the colon the same technic can be used, omitting, of course, the valve construction feature.

Only an inch of ileum is projected into the colon because if there were more the eversion of the mucosa of the ileum would probably not be sufficient to cover the peritoneal surface of the ileum which lies within the colon, and

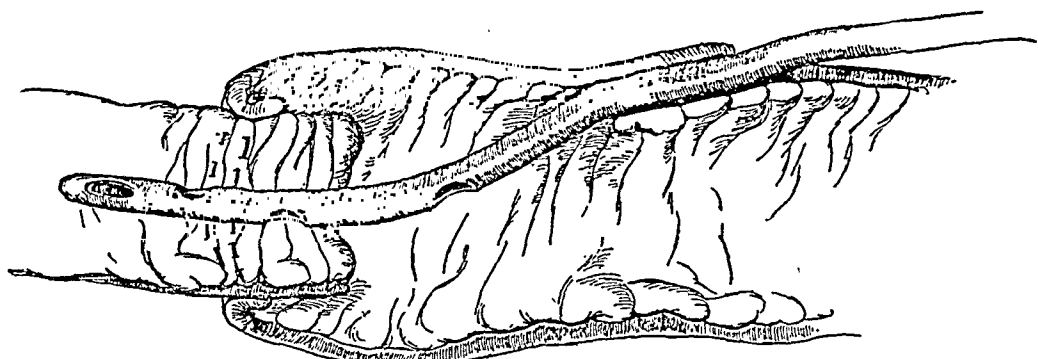


FIG. 7.—Section shows the union of the ileum and colon complete with the enterostomy tube in position. Note the oblique manner in which the tube is introduced.

this excessive amount of peritoneal surface would be subjected to the irritating effect of the contents of the colon and contraction might result.

After operations on the colon, gas is often annoying. A. J. Oschner has written fully of this complication (*Journal A. M. A.*, vol. lxvii, p. 483). On the left side it may be avoided by passing a tube from the anus through the intestinal union at the time of operation. On the right side, however, the tube would be too long and might exert injurious pressure at the flexures. I believe an enterostomy with a soft rubber catheter would be advisable. I have not yet done this in resection of the cæcum and colon, but it could be easily performed and should add but little danger to the resection. The method of enterostomy I have used frequently in intestinal obstruction is based on the principle of Coffey of forming a valve of the mucosa and is shown by the illustrations. An incision about two inches long is made with a sharp knife down to the mucosa. A purse-string suture is placed at one end and the mucosa within the grasp of this suture is punctured (Fig. 4). A soft rubber catheter is quickly inserted through the puncture, the purse-string suture tied snugly, and an end of

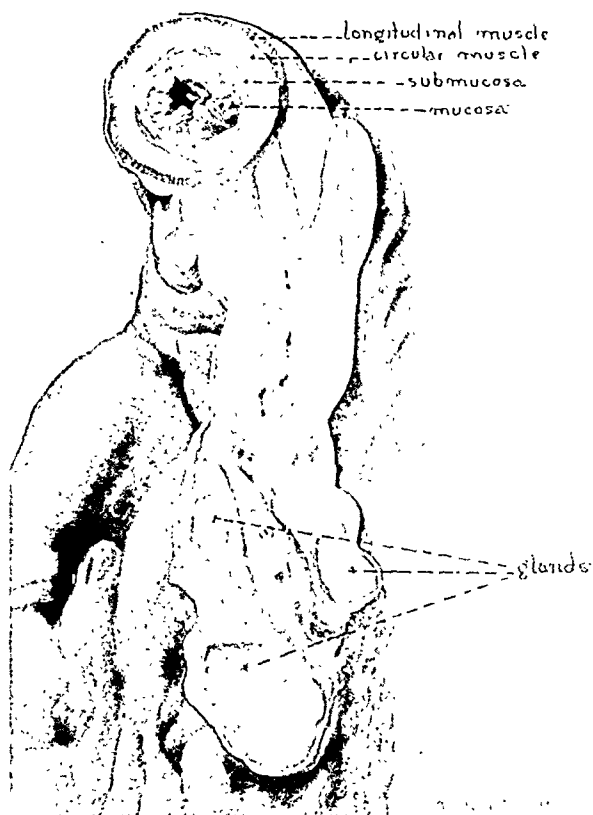


FIG. 8.—Hypertrophic tuberculosis of the cæcum. Drawing of a transverse section of specimen removed from Mrs. D.

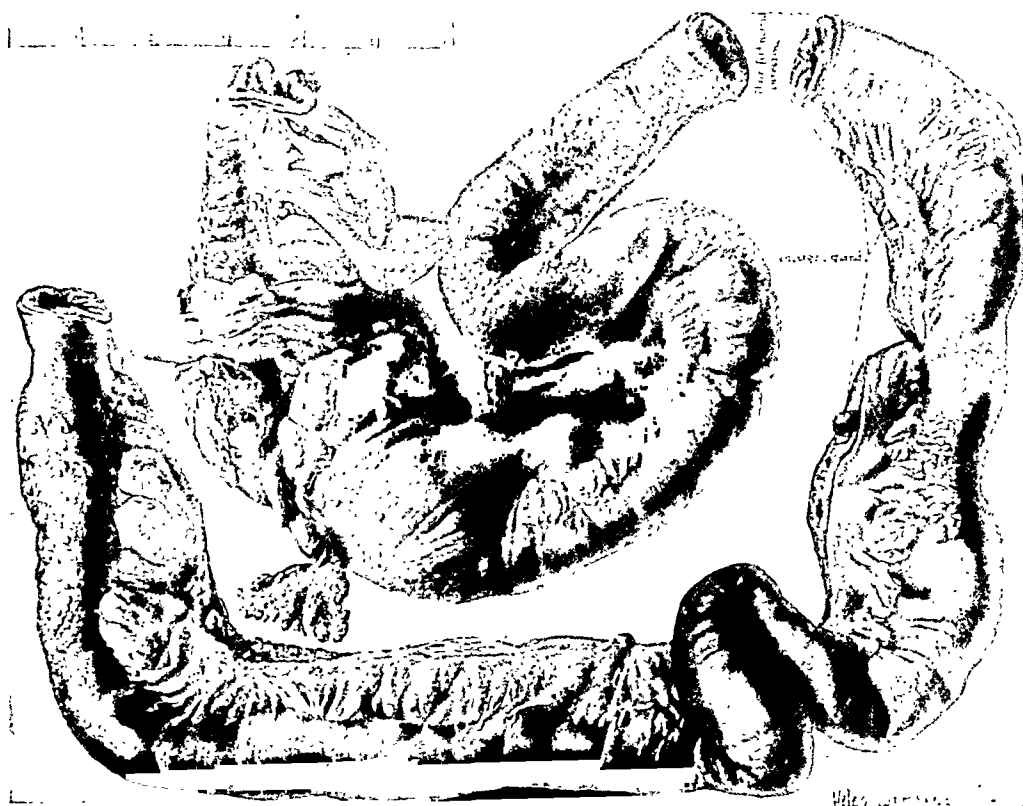


FIG. 9.—Drawing of the exterior of specimen removed from Mrs. D. Note the portions of the ileum that are covered with tubercles and the marked contraction of the ileum at one point. There was no evidence of any other tuberculosis in the abdominal cavity. After resecting that part of the intestine including the cæcum and ascending colon, a separate resection was made of the segment of diseased ileum.

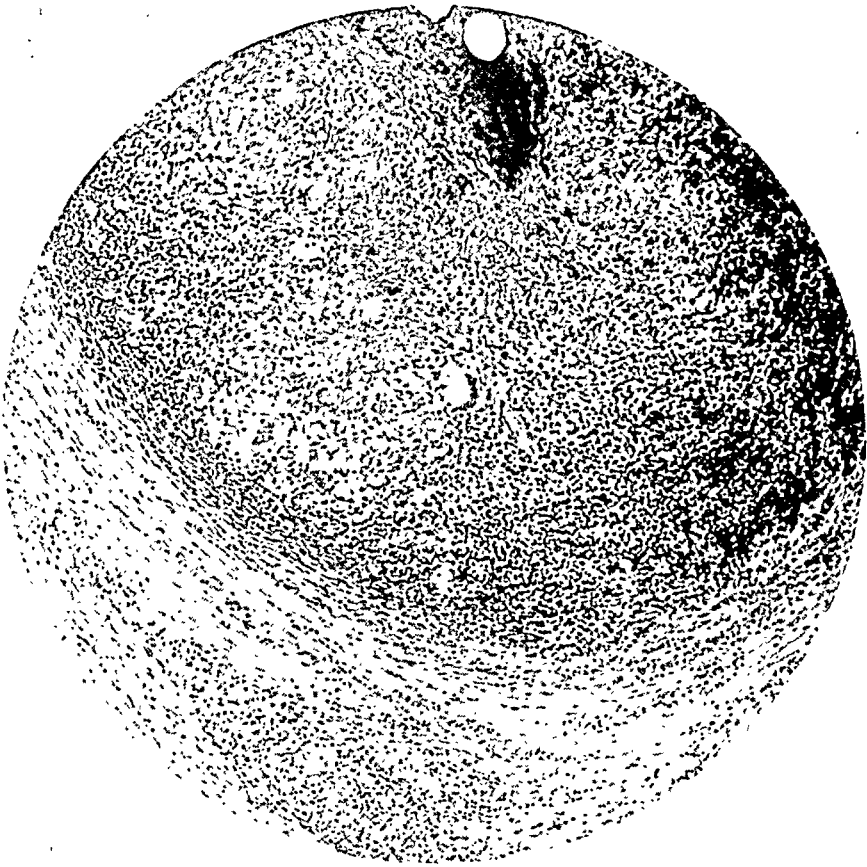


FIG. 10.—Photomicrograph (x85) of section of one of nodules of the specimen shown in FIG. 9, showing giant cells and other typical histologic structure of a tubercle.

RESECTION OF THE CÆCUM AND ASCENDING COLON

the suture is threaded in a needle and transfixes and holds the catheter in place. The portion of the catheter over the incision is then buried with a right-angled suture (Figs. 5 and 6). The catheter will stay in position at least five or six days and when removed there is little or no leakage of fecal contents. In connection with resection of the cæcum and colon a catheter with several perforations could be introduced through a stab wound in the abdominal wall, placed in the colon near the resection in the manner described, and carried through the intestinal union into the ileum. It should be so placed that at least one of its perforations would be in the colon while its tip rests in the ileum (Fig. 7).

The series of seven cases of resection of the cæcum and ascending colon herewith reported comprise all the operations of this kind that I have done since January 1, 1908. In all of them the principles of end-to-end union, ligation of the triangular space on the mesenteric border of the bowel before opening the bowel, and cleaning out the ends of the bowel before suturing were carried out, though in only the last case was a valve formed as described. In one case, the Barber operation was performed (W. H. Barber, *Interstate Med. Jour.*, 1917, vol. xxiv, No. 1), transplanting the ileocæcal valve. All of the patients recovered from the operations satisfactorily. An enterostomy was not done in any of these cases, though I believe, in at least two, convalescence would have been more comfortable had it been used. I will add this to the technic in the future.

The last patient, Mrs. G., operated on September 14, 1917, had marked intestinal stasis and thickening of the cæcum and ascending colon and the technic was carried out as described, including the valve formation. This patient was fifty-five years of age and had been an invalid for years, having been confined to bed most of the time for a year and a half previous to operation. She had been treated by a number of very competent physicians in other hospitals and at her home with only slight and temporary benefit. When she entered the hospital for operation she weighed 82 pounds. She began gaining weight about two weeks after operation and within five months gained 36 pounds. She now weighs 115 pounds and is doing her own housework for a family of two (November, 1918). She still has a few nervous symptoms, though they are comparatively insignificant.

Two of the resections were done for intussusception in infants (aged nine and ten months respectively). In one it was impossible to reduce the intussusception; in the other after it was reduced with considerable difficulty the bowel was so damaged that it was thought unwise to leave it. Two of the resections were for stasis in cases in which medical treatment and in one instance two previous operations had failed to give relief. One of these cases, Mrs. G., has been mentioned. In the other, Mrs. M., aged fifty-two, the Barber operation was done and there was marked improvement though not so great as in the case of Mrs. G. In three cases (aged fifty-seven years, twenty-eight years, and sixteen years respectively) resection was done for hypertrophic tuberculosis of the cæcum. One of these

patients has been reported in connection with another group of cases (*Trans. Southern Surg. Association*, vol. xxi, p. 212). In all three the pathologic findings were quite similar. In one, Mrs. D., aged fifty-seven years, it was thought that the growth was cancerous, but gross section and microscopic examination showed typical features of hypertrophic tuberculosis. There was also tuberculosis of several loops of small bowel which were removed. The ileum was united to the stump and then the other affected portion of the ileum was resected (Figs. 8, 9, and 10).

NOTE.—Since this paper was written I have resected the cæcum and ascending colon in another patient, making a total of eight cases of this kind in which this operation has been done. The valve formation and the enterostomy were carried out as described. At present (five days after operation) the patient is making an entirely satisfactory recovery. Her pulse has not been over 104 since the operation. There has been no distension.—J. S. H.

TORSION OF APPENDICES EPIPLOICÆ *

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(From Division of Surgery, Mayo Clinic)

THE appendices epiploicæ appear along the whole of the large intestine except the rectum, where they terminate quite abruptly. They consist of little processes or pouches of peritoneum; no other part of the intestinal wall enters into their formation, the space or sacculation being filled with a variable amount of fat, usually considerable in obese persons. Their shape and size is variable, usually dependent on their fat content. They are often more or less flattened but may be quite cylindrical. When flat they are usually lobulated. Their size is variable along the course of the large bowel and in different persons, the smallest occurring along each side of the mesentery of the appendix vermiformis. The development is moderate on the ascending and descending colon, and the greatest size is usually on the transverse colon and sigmoid flexure. Their length varies from 0.5 to 5 cm., but they have been reported 15 cm. in length (Linkenheld). As a rule but one artery and one vein enter the base of each appendix epiploica. The appendices epiploicæ occur quite evenly in two rows, their line of origin usually being quite close to the anterior and posterior inferior longitudinal muscle bands.

Harrigan quotes Robinson in saying that the physiologic function of appendices epiploicæ is not protective and defensive like the great omentum, as they are simple in structure and present no evidence of specialized function. It is Robinson's belief that these appendices epiploicæ are concerned with the movement of fluids in the large intestine; however, no definite evidence of their true function has been brought to light.

The pathologic changes incident to the appendices epiploicæ are usually those attending mechanical interference with their blood supply either by torsion or direct pressure, torsion being perhaps the only cause within the abdomen—that is, not limited to the abdominal cavity. A considerable number of cases have been reported in which torsion of an appendix epiploica has occurred in a hernial sac, this being the most common site for mechanical interference by direct pressure and strangulation without torsion; however, torsion occurs here also. In either event the interference with the circulation may be suddenly complete or gradually progressive. Fat necrosis is the chief degenerative change, there being frequently considerable inflammatory reaction, particularly in those cases of hernia in which it is manifested by

* Submitted May 15, 1918, to the Faculty of the Graduate School of the University of Minnesota in partial fulfilment of the requirements for the degree of Master of Science in Surgery.

the adhesions which frequently close off the neck of the sac, and by the presence of serum (Servé, Kendirdjy and Sejournet, and Schweinburg cases). Subperitoneal hemorrhagic effusions occur (Lorenz, Zoeppritz, Mohr, Schweinburg, and Linkenheld cases) and at times only small ecchymotic areas with dark discoloration of the appendix epiploica have been seen. In the abdominal cavity these same changes take place, with torsion, and several appendices epiploicæ may adhere over the one in which torsion has occurred, in a way suggesting protection. The affected appendix epiploica then becomes encysted, and fat necrosis and saponification take place until the cyst contains but an oily straw-colored fluid, as was seen in Case A43949.

Since all cases of torsion of an appendix epiploica present acute pathologic processes, characterized by subperitoneal hemorrhagic effusion, fat necrosis, gangrene, etc., infection of the appendix epiploica by direct microbic invasion from the lumen of the bowel because of interrupted continuity, as is seen in diverticulitis of the colon, seems a very probable etiologic factor. Many authors have noted the frequent presence of diverticula in relation to the appendices epiploicæ. Telling says: "Bland Sutton has stated and illustrated by diagrams that this fat is directly continuous with the subserous fat, and if there is any tendency to the formation of diverticula, it will be readily seen that the soft fatty tissue of the appendices epiploicæ form points of lowered resistance." McGrath states that the relationship between diverticula and appendices epiploicæ seems to be due to the fact that these fatty masses are situated either directly on or close to the points where the larger vessels enter the intestinal wall. Greaves reports a case in which there was an active inflammatory process in two appendices epiploicæ of the pelvic colon. They were nodular, black in color, and each one contained a fecal concretion, but no communication with the lumen of the bowel could be found. However, while torsion of these appendices epiploicæ had not occurred, the inflammatory process was undoubtedly due to microbic invasion by way of a diverticulum. Erdmann found, in most of his cases of acute diverticulitis of the colon, involvement of one or more appendices epiploicæ, which were usually very hard and injected or hemorrhagic and becoming gangrenous.

In some of the cases of diverticulitis of the colon with tumor formation seen in the Mayo Clinic, the appendices epiploicæ have been found involved in the inflammatory process in a way suggesting protection to perforation of the diverticula. Virchow's case in which colon bacilli were cultivated from the centre of a foreign body found in the peritoneal cavity, as the sole cause of a peritonitis, adds evidence to the infection theory. Diverticulitis was not found in any of the cases of torsion of appendices epiploicæ reported in the literature, nor was it demonstrated in our cases, yet it seems that infection may prove to be the etiologic factor in the production of torsion and of inflammation in appendices epiploicæ.

Torsion intra-abdominally of an appendix epiploica may suddenly deprive it of its circulation, and with no protection from the omentum or neighboring appendices epiploicæ, necrosis of the narrow pedicle occurs so rapidly that

TORSION OF APPENDICES EPIPLOICÆ

it drops off and remains in the peritoneal cavity as a free body, encysted by its peritonéal coat. Such fatty bodies have been found in 4 cadavers (Littre, Laveran, Cruveilhier, and Virchow), and in 5 instances at operation (Schede, Neri, Riedel 4, and Case A210428). Of those found in the cadavers, one contained a stone, and in two the foreign bodies were fibrocartilaginous. The case of Virchow showed an atrophied appendix epiploica as a possible source of the foreign body. The foreign bodies found at operation retained their fatty composition in all cases except one (Schede) in which calcification of the body had occurred. These foreign bodies varied in size from the size of a pea to a hen's egg. Colon bacilli were isolated from one of the bodies (Riedel's fourth case) as the source of a fatal peritonitis. In four of these cases operation was done for acute or subacute conditions and nothing else was found to explain the symptoms.

DISCUSSION OF CASES REPORTED IN THE LITERATURE

The literature contains records of forty-two cases which have accumulated under the combined titles of "torsion and inflammation of appendices epiploicæ." It seems advisable to divide these cases into their true classifications, rather than into one large group, according to the pathologic condition presented.

Nineteen were cases of true torsion of an appendix epiploica, intra-abdominal in 9 cases and within a hernial sac in 10. One case of intra-abdominal torsion was a finding at necropsy, the remainder were seen at operation and each presented an acute process. The intra-abdominal cases possessed symptoms of acute surgical conditions in which the diagnosis of acute appendicitis was made in three instances, intestinal obstruction in two, gallstones in one, ovarian disease in one, and appendicitis and gall-bladder disease in one. There were no pathologic findings to explain the acute symptoms, except the torsion of the appendices epiploicæ.

The ten patients with hernias in whom torsion of an appendix epiploica had occurred all had acute symptoms on which the diagnosis of strangulation or incarceration of the hernial contents was made. In twelve cases of hernia in which the symptoms were acute there were from one to three strangulated or incarcerated appendices epiploicæ, showing the inflammatory reaction and fat necrosis attending mechanical interference with blood supply without torsion of the pedicles.

The literature contains accounts of eleven cases of foreign body in the peritoneal cavity which are assumed to have been the results of torsion of appendices epiploicæ, and while evidence in its support is presented in but one case (Virchow) in which there was found an atrophied appendix epiploica the possible source of the foreign body, that assumption is probably correct. However, in the absence of facts establishing these cases as true torsion of appendices epiploicæ, it seems they should not be classified in that group.

One case (Patel) from the report is a true case of diverticulitis, for which the diagnosis is easily mistaken.

Excluding the last 12 cases, the literature contains but 30 cases in which there has been mechanical interference with the blood supply of an appendix epiploica, and in 19 of these it was by torsion. The symptoms in each of these 30 cases were of sufficient severity to require urgent surgical interference.

Several theories regarding the cause of intra-abdominal torsion of appendices epiploicæ have been advanced. Morestin states that for torsion to occur it is necessary that these fatty appendages should be abnormally long and large. Ebner quotes Payr's theory of the difference of length of artery and vein, the vein being the longer by reason of its winding course. In congestion, particularly in stasis with engorgement of the veins, this difference of length may furnish the tendency to the twisting of the pedicle.

Zoeppritz's patient had an adhesion to the omentum, which, on sudden movement in the abdomen, due to a quick turn of the patient, may have been responsible for the torsion of the appendix epiploica. Zoeppritz quotes Küstner, Mickwitz, and Cario as regards external causes, such as peristalsis and variations in the filling of the abdominal organs, contraction of the abdominal muscles and the effect of abdominal pressure, being sufficient to cause torsion of intraperitoneal bodies.

Torsion of an intrahernial appendix epiploica is explained by Ebner in a certain case by its twisting on its exit into the hernial ring at the moment of coughing, similar to the spiral twisting of a cloth used in cleaning a lamp chimney; the tip of the appendix epiploica follows along the wall of the sac, and its base or pedicle remains more or less fixed. In some instances the appendices epiploicæ are carried into the hernial sac with omentum and torsion is produced.

DISCUSSION OF CASES FROM THE MAYO CLINIC

To the cases reported in the literature I desire to add 11 cases which have been under observation in the Mayo Clinic in the past ten years. Seven of these cases are true torsion of the appendix epiploica, 1 is of doubtful torsion, acting as a band producing intestinal obstruction, 2 are of incarceration in a left inguinal hernia, and 1 is of a foreign body in the peritoneal cavity with unproved origin from an appendix epiploica. Four of the cases of torsion presented acute symptoms, for which operation was done, and in the remaining 3 cases the torsion was probably symptomless, as it was found in the course of abdominal operations for other pathologic conditions. The cases in which there was incarceration in a hernial sac presented symptoms of incarceration of the hernial contents. The foreign body was found in the course of an operation for postoperative hernia, and the appendix epiploica, producing the obstruction of the sigmoid, manifested symptoms of chronic intestinal obstruction.

It may be seen from the histories of cases from the literature and those included in our series that intra-abdominal torsion produces symptoms, acute in various degrees, simulating those of gall-stone colic, acute appendicitis, intestinal obstruction, etc., the pain not necessarily occurring directly over the

TORSION OF APPENDICES EPIPLOICÆ

seat of the lesion, for, while the sigmoid has been the portion of the bowel most frequently affected, the pain has in many instances been in the right abdomen. In the combined series of cases (40) in which mechanical interference with the blood supply to the appendix epiploica had occurred, the origin of the appendix was in the sigmoid in 28 instances, in the cæcum in 6, in the transverse colon in 1, and not stated in 5. Left inguinal hernias are more apt to contain epiploic tags because of the close proximity of the sigmoid, with its long mesentery, to the internal ring of a left hernia. In the 24 cases of torsion or strangulation of the appendix epiploica in a hernial sac, it was found in a left inguinal hernia in 17 instances, in a right inguinal hernia in 5 and in a left femoral hernia in 2.

The amount of torsion of the appendices epiploicæ has varied from one turn through 180° (Zoeppritz) to ten half turns (Adler). It has been stated (Briggs) that torsion of appendices epiploicæ usually occurs in persons more or less obese, during middle life or later. In 24 of the 26 cases of torsion, in which the age was given, the youngest patient was 20 years and the oldest 72, an average age of 45 years—5 each in the third and fourth decades, 4 in each of the fifth, sixth, and seventh, and 2 in the eighth decade.

Intra-abdominal torsion occurred 11 times in the male and 5 times in the female. Within a hernial sac it occurred 6 times in the male and 4 times in the female, the males comprising 65+ per cent. of the entire series of torsion.

ABSTRACTS OF REPORTS OF CASES IN THE LITERATURE

Appendices Epiploicæ as Foreign Bodies

CASE I.—In 1703 LITTRÉ, during the dissection of a cadaver, found in the abdomen a free, hard, oval body, one inch long. In its center was a round white stone, the size of a pea.

CASE II.—In VIRCHOW'S case the patient died of peritonitis. A hard, calcified, foreign body was found in the abdominal cavity, the possible source being an atrophied appendix epiploica of the vermiform appendix.

CASE III.—In 1894 SCHEDE reported a patient who had symptoms of ileus, and at operation a free body, hard and the size of an egg, was removed from the pelvis and found to be a calcified appendix epiploica.

CASE IV.—In 1894, CRUVEILHIER, at necropsy after death of unknown cause, found a large foreign body, with white, smooth surface, very hard and perfectly free, in the abdomen.

CASE V.—In 1895 LAVERAN at necropsy found a mass of twelve fibro-cartilaginous bodies in the abdomen.

CASE VI.—In 1904 NERI found at operation several foreign bodies composed of fat within a connective-tissue envelope.

CASE VII.—In one of RIEDEL'S group of cases reported in 1905, the patient had attacks of pain simulating gall-stone colic and a diagnosis of adhesions about the gall-bladder was made. At operation two foreign bodies, almost as large as a cherry, were removed. The pains recurred, and three years later the patient committed suicide. The necropsy revealed two more foreign bodies free in the peritoneal cavity.

CASE VIII (RIEDEL).—The patient was a male, 25 years of age, who four years previously had been operated on for an appendiceal abscess, with removal of the distal end of a gangrenous appendix. He had three indefinite attacks of pain with abscess

formation in the umbilical region. Operation disclosed two small, yellow, round foreign bodies.

CASE IX (RIEDEL).—The patient was a male, 32 years of age, whose symptoms were those of gall-stone colic with jaundice. At operation the gall-bladder contained no stones. The omentum was adherent to the liver and the transverse colon, and two foreign bodies were slightly adherent to it. They were round and calcareous. A number of appendices epiploicæ were hanging by a mere thread from the transverse colon.

CASE X (RIEDEL).—The patient, a female, 41 years of age, had been sick for eight days and presented the symptoms of peritonitis. At operation there were marked signs of peritonitis. A crescent-shaped appendix epiploica, attached to the descending colon, with a flat, grey, foreign body lying free between it and the abdominal wall, seemed to be the sole cause of the peritonitis. The appendix epiploica was not twisted. Colon bacilli were found in the foreign body, which was composed of fat. The patient died on the third day after operation, and necropsy did not disclose any other cause for the peritonitis.

CASE XI (RIEDEL).—The patient had been vomiting for fourteen days, the vomitus at last becoming fecal. A diagnosis of intestinal obstruction was made. At operation a foreign body the size of a bean lay free in the peritoneal cavity. The parent appendix epiploica seemed to spring from the cæcum and was adherent to a coil of small intestine in such a way as to act as a constricting band, the small intestine being greatly distended. The foreign body was composed of fat, and Riedel considered it a part of the appendix epiploica, from which it had become separated by torsion.

Intra-Abdominal Torsion of Appendices Epiploicæ

CASE XII.—In a case of TOMELLINI'S, of a man dead of cardiac paralysis, necropsy revealed that the appendices epiploicæ of the transverse colon and sigmoid were straighter than usual. A flattened appendix epiploica was found the same color as the others, and bound to the mass by a thin pedicle. This pedicle had undergone a true torsion around its long axis.

CASE XIII (RIEDEL).—This patient was a man 40 years of age, who, three days before admission, complained of severe abdominal pain, vomiting, etc., and presented the picture of intestinal obstruction. At operation there was free fluid in the abdomen, the jejunum was greatly dilated, the ileum less so. Arising from the left wall of the cæcum, an appendix epiploica stretched across the ileum and was adherent by its twisted middle portion to the mesentery of a coil of small intestine. The ileum was greatly contracted by the appendix epiploica, acting as an obstructing band, and was relieved by the removal of the appendage. Enterostomy was done to relieve the obstruction. The patient died on the following day and necropsy disclosed peritonitis.

CASE XIV.—BRIGGS in 1908 reported the case of a male, 35 years of age, without a history of previous abdominal complaint. He had had a sudden attack of right lower abdominal pain, which gradually subsided, but increased later in the day. The pulse and temperature were normal. A tumor was palpable over the tender region of the appendix. On the fifth day, with the patient's temperature 100° F., operation was performed. Presenting in the incision was a tumor 1½ inches long and 1 inch wide, having the appearance of a hæmatoma with a peritoneal envelope. It was adherent to the cæcum by a narrow twisted pedicle. The appendix vermiformis, though normal, was removed. The tumor was an appendix epiploica with a twisted pedicle.

CASE XV.—ZOEPPRITZ reported a case in 1909 in which the patient was a male, 20 years of age. For three weeks he had burning pains in the right epigastrium, extending toward the midline. Before examination he had acute epigastric pain and there was tenderness at McBurney's point. The diagnosis lay between acute appendicitis and acute cholecystitis. The appendix vermiformis appeared in the incision and did

TORSION OF APPENDICES EPIPLOICÆ

not seem to be the cause of the acute symptoms. Upon lengthening the incision a brownish, bluish-red mass the size of a plum appeared in the wound, from the center of which extended a slightly thickened band of omentum. The removed tumor was an appendix epiploica of the beginning of the transverse colon twisted 180° . When the omentum was loosened there was no tendency to untwist.

CASE XVI.—In EBNER's case reported in 1909 the patient was a male, 65 years of age, who had had a right inguinal hernia for fifteen years and a left inguinal hernia for a shorter length of time. Seven days before examination, after lifting a heavy load, he felt severe pain in the right side of the abdomen. The hernia could be reduced, but three days later there was much hypogastric distention and tenderness, with moderate increase in temperature for two days. Retention of fæces and flatus with vomiting occurred, a diagnosis of intestinal paralysis was made and immediate operation performed. There was a small amount of clear, bloody fluid in the abdominal cavity and a pedunculated fat tag 15 cm. long, arising from the sigmoid and extending from the left inguinal region over to the right side by a thin pedicle, was twisted through 180° . This proved to be an appendix epiploica. As a result of the torsion, congestion and extravasation of blood had occurred in the fat tag. After operation the symptoms of intestinal paralysis were progressive and the patient died on the seventh day. The author explains the intestinal paralysis as being due to the coagulation processes in the mesenteric vessels following torsion of the appendix epiploica.

CASE XVII.—POCHHAMMER in 1910 reported a case of a patient, a male, 34 years of age, who had during the past eighteen years repeated attacks of pain in the right lower abdomen which had been diagnosed as appendicitis. He had a similar attack just before admission to the hospital, with no nausea or vomiting. From the history and examination the diagnosis of appendicitis was made and operation performed. In the pelvis was found a hard, fatty tumor the size of a hen's egg, bluish-black in color and its central portion was infiltrated with blood. It was evidently an appendix epiploica, which had become enlarged from fatty infiltration, and the pedicle had become twisted. The vermiform appendix was shrunken and showed no evidence of inflammation, but was removed.

CASE XVIII.—MORESTIN reported a case in 1912 in which the patient was a female, 30 years of age, who ten days before examination experienced sudden severe left abdominal pain with nausea and moderate temperature for twenty-four hours. Four days after the onset a tender mass the size of a large egg, separate from the uterus, could be felt in the left side of the pelvis. A diagnosis of left tubo-ovarian disease was made and operation performed, at which time atrophy of the uterus and its appendages was found. A mass in the left side of the pelvis in the middle of a few blood clots and recent adhesions, purplish in color, with some attachment to the uterus and broad ligament, had its origin in the sigmoid by a narrow pedicle, twisted upon itself, and proved to be an appendix epiploica. The patient's convalescence was uneventful.

CASE XIX.—KIMPTON reported a case in 1915 of a patient, an obese male, 42 years of age, who had had acute pain in the right lower quadrant of the abdomen, with nausea. He had had one or two previous similar attacks. The lower right quadrant of the abdomen was rigid and tender, the pulse and temperature were normal. A diagnosis of acute appendicitis was made, and at operation a black appendage of fat presented in the region of the appendix vermiformis, which was a twisted appendix epiploica. It was removed, and, although the vermiform appendix was normal, appendectomy was done. Further abdominal exploration was negative. The twisted appendix epiploica was hemorrhagic and necrotic. The convalescence was uneventful.

CASE XX.—HARRIGAN in 1917 reported a patient, a male, 29 years of age, who two days before examination had sudden severe pain in the right lower quadrant of the abdomen, with no radiation, which became progressively worse in spite of the use of opiates. Physical examination was negative except for a slight rigidity and tenderness over McBurney's point. The temperature was 100°F. , pulse 98 and respiration 24.

A diagnosis of acute appendicitis was made and immediate operation performed. The vermiform appendix was not inflamed and general exploration of the abdomen was negative except in the sigmoid, where an appendix epiploica presented evidence of acute inflammation, the pedicle being twisted. The appendix epiploica was removed by ligation of its pedicle and the vermiform appendix removed, with the patient's complete recovery.

Intrahernial Torsion of Appendices Epiploicæ

CASE XXI (RIEDEL).—The patient was a female, 20 years of age, who had had a left reducible femoral hernia for ten years and an irreducible right femoral hernia for a few months. On the day before examination the patient had violent abdominal pain with tenderness of the left femoral hernia. At operation the next day a fatty structure 1 cm. by 5 mm. was found suspended from the wall of the sac by a thin pedicle of fibrin. The case seems to have been one of torsion.

CASE XXII (RIEDEL).—The patient was a female, 56 years of age. For two years she had had a right inguinal and a left femoral hernia. Two days before admission to the hospital the patient suffered with severe pain in the left groin, and the femoral hernia was then an irreducible tumor. Immediate operation showed an appendix epiploica twisted once on its axis and adherent by its distal extremity in the hernial sac. Necrosis had already begun. The pedicle was ligated and the appendix epiploica removed, with radical cure of the hernia and recovery.

CASE XXIII.—SERVÉ in 1906 reported the case of a male patient, who had had a left inguinal hernia for many years in which two days before examination he experienced a violent pain following a severe muscular effort. The scrotum was swollen, and at operation a few drops of fluid escaped from the hernial sac which revealed as the content an appendix epiploica 10 cm. long, completely twisted on itself. This was removed and radical cure of the hernia was followed by recovery.

CASE XXIV.—MUSCATELLO in 1906 reported a case of a patient, a male, 38 years of age, who had experienced a sudden pain in the left inguinal region six months previously, the pain disappearing for a month. He had a left inguinal hernia extending into the scrotum, which at operation contained omentum in the sac and an appendix epiploica adherent to the posterior border of the neck of the sac and twisted on itself. The torsion occurred 5 mm. from the insertion of the appendix epiploica on the colon. Removal of the appendix epiploica and radical cure of the hernia were followed by recovery.

CASE XXV.—In 1907 MOHR reported a case of a patient, a male, 62 years of age, who had had for the past three to four years a reducible tumor of the left inguinal region, which ten days before examination became irreducible. On the diagnosis of strangulated hernia operation was performed, and in the hernial sac an appendix epiploica was found which presented hemorrhagic infiltration. The tips of two other appendices epiploicæ presented in the sac, springing from the sigmoid, and were in a state of torsion with gangrene imminent. They were removed; the patient recovered.

CASE XXVII.—KRÜGER reported in 1907 the case of a patient, a male, 56 years of age, had a right inguinal hernia, much abdominal pain and symptoms of intestinal obstruction. Operation revealed in the hernial sac, among loops of intestine and inserted mesially to the neck of the sac, a narrow, tense, pseudo-ligament about 6 cm. long, and around which an appendix epiploica, arising from the colon, had become twisted and strangulated, torsion being through 360°. The immediate visceral and parietal peritoneum was covered with fresh fibrin, and the twisted appendix epiploica showed subperitoneal effusions of blood and gangrene of the pedicle at the point of strangulation. The band and appendix epiploica were resected, with good recovery.

CASE XXVII.—KRUGER reported in 1907 the case of a patient, a male, 56 years of age, who had had an attack of pain in the right groin twenty years before, which disappeared after a few weeks, to recur two years previous to admission to the hospital

TORSION OF APPENDICES EPIPLOICÆ

and again four days previously. The pain radiated from the urethra to the umbilicus. There was a firm mass in the right inguinal region, which, at operation, proved to be an appendix epiploica 4 cm. by 1.5 cm., springing from the cæcum by a short pedicle, which had passed through the inguinal canal and become twisted in the hernial sac, giving rise to the inflammatory symptoms. The appendix epiploica was removed, with radical cure of the hernia.

CASE XXVIII.—In 1908 ADLER reported a case in which the patient, a robust woman, 72 years of age, had had a left reducible inguinal hernia for twenty years. The day before admission to the hospital the hernia became irreducible. An operation was done immediately and a cord-like mass lying in an œdematous sac was found. The mass was of omental tissue, which ended below in an enlargement the size of a chestnut. The cord was twisted on itself and contained ten half turns, the whole lying quite free in the hernial sac. On following the cord down, it was found to have its origin from the large intestine and proved to be an elongated twisted appendix epiploica. The hernia was repaired and there was an uninterrupted recovery.

CASE XXIX.—In 1908 LINKENHELD reported the case of a patient, a fleshy man, 64 years of age, in whom eight days previously a painful, irreducible swelling had appeared in the right inguinal region. A diagnosis of strangulated omental hernia was made. At operation the hernial contents were found to consist of omentum and a twisted connective-tissue cord extending up into the abdominal cavity. This was ligated and the omentum removed, with radical cure of the hernia. The patient died on the sixth day from gastric hemorrhage, and necropsy showed multiple ulcers of the stomach; also six long, thick and fat appendices epiploicæ of the sigmoid were found with the tied pedicle of the cord in the hernial sac.

CASE XXX.—In 1910 KENDIRDJY reported a case of a patient, a male, 43 years of age, who had had a left inguinal hernia for twelve years. Two weeks before examination severe pain in the hernia and swelling were noted. Two days before examination symptoms of intestinal obstruction appeared and the skin overlying the hernia was inflamed and tender. When the hernial sac was opened, some yellow fluid escaped, and a yellow fatty mass, presenting ecchymotic areas, formed its contents. This was attached to the sigmoid by a pedicle, in which torsion one and one-half times had occurred. The pedicle was ligated, with radical cure of the hernia and recovery.

Intrahernial Strangulation or Incarceration of Appendices Epiploicæ

CASE XXXI.—In 1906 VON BRUNS reported the case of a patient, a female, 55 years of age, who had had a left inguinal hernia for four years. It became suddenly painful, swollen and irreducible, the overlying skin becoming red and œdematous. At operation a small amount of fluid escaped and revealed a gangrenous strangulated appendix epiploica, which was removed, and good recovery occurred.

CASE XXXII.—MUSCATELLO reported a case in 1906 of a patient, a female, 56 years of age, who was suddenly attacked by violent femoro-inguinal pain on the left side, radiating all over the abdomen and in which the diagnosis of strangulated femoral hernia was made. Operation under local anæsthesia allowed the escape of clear yellow fluid and the exposure of two appendices epiploicæ, measuring 2 and 1.5 cm., respectively, attached by narrow pedicles to the sigmoid. The appendices epiploicæ were removed and the sac resected, with a radical cure of the hernia and recovery of the patient.

CASE XXXIII.—In 1906 SCHWEINBURG reported the case of a patient, a male, 45 years of age, who had had a reducible left inguinal hernia for years. Six days before admission to the hospital the hernia became irreducible and painful and tender. At operation the hernial sac contained odorless fluid and three appendices epiploicæ, which were thickened and hemorrhagic, and, on being drawn down, were found to have their origin from the sigmoid. They were removed, with radical cure of the hernia and recovery.

CASE XXXIV.—VERGA reported a case in 1907 of a patient, a female, 46 years of age,

who developed a right inguinal hernia at 23 years of age and a left inguinal hernia at 26, both of which remained reducible until eight days before examination, when the left hernia could not be reduced. There was some pain from it, radiating to the hypogastrium, but no nausea, vomiting or evidence of intestinal obstruction. In the left inguinal region there was a mass the size of an almond, which was tender. On the diagnosis of an irreducible hernia, operation was performed November 4, 1906, at which time two appendices epiploicæ were found strangulated in the hernial sac, showing vascular engorgement and several hemorrhagic points. They originated from the sigmoid. They were ligated and cut off and the hernia repaired, with good recovery.

CASE XXXV.—VULLIET reported a case in 1907 of a patient, a male, 62 years of age, who had had a double inguinal hernia for twenty years. There was severe pain in the left inguinal region three days before admission to the hospital. At operation the left hernial sac contained two appendices epiploicæ with thin pedicles extending to the sigmoid. Removal of the appendices epiploicæ and radical cure of the hernia was followed by recovery.

CASE XXXVI.—In 1907 SMOLER reported a case of a patient, a male, aged 37 years, who, on admission to the hospital, complained of nausea and weakness, and who had noticed two days previously that a right inguinal hernia was no longer reducible. On examination the patient was found in a state of moderate shock and an operation was done immediately. The hernial sac was thick and contained bluish-red discolored omentum, with incipient necrosis due to torsion of 360° of that part of the omentum. By the side of the omental mass, at the median side of the hernial aperture, a structure as thick as the finger and 2 cm. long presented, which proved to be an appendix epiploica of the sigmoid. The omentum and appendix epiploica were removed, with death of the patient on the fifth day.

CASE XXXVII.—In 1908 LINKENHELD reported the case of a female, 57 years of age, in whom there appeared, eight days before examination, a swelling in the right inguinal region which caused severe pain. The swelling was firm and tender. At operation strangulated in the neck of the hernial sac was a piece of fat the size of a hazelnut. After freeing the adhesions the fat tag could be withdrawn. It exhibited a distinct constriction and proved to be an appendix epiploica, probably of cæcal origin.

CASE XXXVIII (LINKENHELD).—The patient, a male, 71 years of age, had had a left inguinal hernia for a year, in which, two days before admission, pain, swelling and reddening of the skin occurred, with no symptoms of obstruction. The hernia was tender to pressure. At operation the contents of the hernial sac consisted of three appendices epiploicæ, one the thickness of the finger and the other two the thickness of a lead pencil. They were swollen, reddened and infiltrated with blood, being strangulated at their upper ends. Two days later the patient died from ruptured aneurysm, as revealed at necropsy, which also showed enlarged appendices epiploicæ of the descending colon and sigmoid.

CASE XXXIX.—TISSERAND in 1908 presented a report of a patient, a male, 36 years of age, who had had a left inguinal hernia all his life, which the past year had at times been painful and irreducible. Sixteen hours before examination he had had a violent colic in the hernia, with some nausea, but no vomiting. Immediate operation disclosed two appendices epiploicæ in the hernial sac, with some free fluid. One appendix epiploica was not strangulated, but the other was swollen, ecchymotic, and in the process of becoming gangrenous from strangulation. Its origin was probably from the cæcum. These appendices epiploicæ were removed, the hernia repaired and the patient had an uneventful convalescence.

CASE XL.—TRUFFI in 1908 reported the case of a patient, a female, 45 years of age, who, about a year previously, noticed a swelling in the left groin, which appeared suddenly and remained for a week. Eight days before examination the swelling recurred. It was painful to pressure, the pain gradually subsided, but the swelling persisted. On admission to the clinic it was the size of a hen's egg and was not

TORSION OF APPENDICES EPIPLOICÆ

reducible. A diagnosis of irreducible hernia was made, and at operation the sac was found to contain a small amount of dark-red liquid and two club-shaped fat bodies, which were covered with numerous hemorrhagic points, and proved to be appendices epiploicæ strangulated at the neck of the sac. They probably originated from the sigmoid. They were removed and the hernia repaired.

CASE XLI (TRUFFI).—The patient, a male, 75 years of age, had had a double inguinal hernia for forty years; the left disappearing of its own accord and the right by operation two years previously. About two months before examination he had had severe pain in the left inguinal region with recurrence of the left inguinal hernia, which was irreducible, with a sense of pressure and pain. Operation was advised. In the sac of the hernia were found two appendices epiploicæ, with strangulation of their pedicles in the neck of the sac. Convalescence was uneventful.

CASE XLII.—In 1912 PATEL reported the case of a patient, a male, 45 years of age, who had had a left inguinal hernia for twenty years. Eight days before admission to the hospital the hernia became irreducible and painful. The overlying skin was red and œdematous, as was the scrotum. The symptoms continued and a diagnosis of strangulated hernia was made. An incision of the hernial sac allowed the escape of a sero-purulent liquid. An appendix epiploica was strangulated in the hernial sac. The tag was ligated and removed. The end of the pedicle had a lumen communicating with the lumen of the large intestine, which proved to be a diverticulum into the appendix epiploica.

CASES FROM THE MAYO CLINIC

True Intra-abdominal Torsion of Appendices Epiploicæ

CASE XLIII (A8716).—R. A. K., a male, fifty-eight years of age, was admitted to the Clinic April 10, 1908. The previous history was negative except for severe constipation for years. Two weeks previously pain was noticed on defecation; there was some mucus in the stool but no blood. The pain continued and was aggravated by enemas. There were no other subjective symptoms. A mass could be felt per rectum, and the diagnosis of a tumor of the sigmoid was made.

Operation was performed April 15, 1908, and an appendix epiploica with a twisted pedicle was found. The pedicle had its origin about five inches above the rectum, and the appendix epiploica had dropped to the bottom of the pouch of Douglas, forming a cystic and adherent mass the size of an orange. The appendix epiploica was removed, with recovery of the patient.

CASE XLIV (A6851).—A. Mc., a carpenter, forty-three years of age, was admitted to the Clinic April 26, 1910. Less than a year previously he had had an appendectomy with negative exploration of the gall-bladder. The history of the present complaint was pain in the right side of the abdomen opposite the umbilicus for four years, very severe at the onset, the patient being in bed four days at that time with diarrhœa and vomiting. The symptoms recurred every two or three months. Appendectomy was performed less than a year previous to examination with recurrence of a similar attack two months later. During the past six months the attacks had been more frequent, the pain lasting from five to six hours and always accompanied by diarrhœa. There was no disturbance of the bowels between attacks, and no radiation of pain. At times there were spells of indigestion, but never any symptoms of organic disease of the stomach or duodenum. Seven days before admis-

sion the patient had had a severe attack of left lower abdominal pain accompanied by vomiting of four hours' duration, and requiring morphine to control. The general physical examination, urinalysis, X-ray examination of the kidneys, ureter and bladder, and cystoscopic examination were all negative.

May 3, 1910, exploration was made of the stomach, gall-bladder and left ureter. These proved negative, but a twisted appendix epiploica of the sigmoid, with its circulation completely cut off, was found. There also were adhesions of the terminal four inches of ileum to the lateral abdominal wall; these were divided and the appendix epiploica removed. Within the next four months there were several recurrent attacks of pain; the further history of the case is not known.

CASE XLV (A38941).—Mrs. F. L., aged twenty-nine years, was admitted to the Clinic June 14, 1910. For seven years the patient had had attacks of moderate pain in the right lower abdomen, usually of only a few minutes' duration, and never severe enough to keep her from her work, but at times they had been of the nature of a dull ache for a day at a time. During the two months preceding examination, there had been moderate digestive disturbance but never any acute attacks of pain. A diagnosis of chronic appendicitis and cholecystitis was made.

June 20, 1910, operation was performed and chronic adherent appendix, and an appendix epiploica, the size of a small pecan, with a twisted pedicle, were found and removed. Exploration of the gall-bladder and stomach was negative.

CASE XLVI (A69658).—Mrs. J. J., aged sixty-three years, was admitted to the Clinic June 24, 1912. The patient had been perfectly well until three months previously, at which time she was confined to bed with burning pain and cramps in the left lower abdomen and much localized tenderness. This had been more or less constant, with the pain radiating around to the sacral region. Constipation, walking, and working aggravated the trouble. Physical examination disclosed tenderness in the left abdomen, moderate œdema of the legs, due to large varicose veins, and complete uterine prolapsus with rectocele and cystocele. X-ray of the kidneys, ureters and bladder was negative.

July 3, 1912, because of the complaint referred to the left lower abdomen, an abdominal operation was done. A calcareous appendix epiploica of the sigmoid, with a twisted pedicle was found. Other exploration of the abdomen was negative. The appendix epiploica was removed and a Kocher abdominal operation done for the prolapsus.

CASE XLVII (A162332).—Mrs. J. B., seventy years of age, was admitted to the Clinic June 10, 1916. Three years previously the patient began having occasional uterine bleeding for a few days at a time, which continued for a year. For two years the discharge had been scant, and six months watery in character. The uterus was enlarged. The menopause had occurred when she was 48 years of age.

June 14, 1916, total abdominal hysterectomy with removal of both ovaries and tubes was done for carcinoma of the body of the uterus and multiple fibroids. Two appendices epiploicæ with twisted pedicles, making a mass the size of the thumb, were found and removed. These were

TORSION OF APPENDICES EPIPLOICÆ

reported by the pathologist to be hemorrhagic. There had been no history of a recent acute abdominal complaint.

CASE XLVIII (A181741).—P. B., a male, aged thirty-seven years, was first seen January, 1917. One month previously the patient had had sudden, severe pain in the left lower abdomen with much localized tenderness which had partially subsided a few days before examination. The patient was a large man who had lost 20 pounds in weight since the onset of the complaint. The urinalysis, blood, and X-ray examination of the colon were negative. A diagnosis was made of probable diverticulitis.

Operation was performed January 5, 1917. A general exploration of the abdomen showed the small intestine and the gall-bladder to be normal, the appendix small, short and normal, and the sigmoid markedly thickened with one epiploic tag about $1\frac{1}{4}$ inches long and $\frac{3}{4}$ inch wide, twisted on its pedicle. Fat necrosis had occurred and the appendix epiploica had become adherent to surrounding epiploic tags. The tags which were involved in the inflammatory mass and the one undergoing necrosis were removed and their stumps ligated. There was no evidence of diverticulitis.

CASE XLIX (A43849).—Mrs. E. A. H., fifty-one years of age, was admitted to the Clinic November 7, 1917. The patient presented herself for examination because of a troublesome watery vaginal discharge, for which hysterectomy was advised. There were no symptoms of an acute abdominal process. She had passed the menopause at thirty-six years of age.

November 12, 1917, total abdominal hysterectomy with removal of both ovaries and tubes, for chronic metritis of the precancerous type, was done. An appendix epiploica of the sigmoid appeared in the wound. It was a round body about 2 centimetres in diameter and was twisted on its pedicle. It had become encysted and contained a clear, straw-colored fluid and oil. There was nothing in the patient's history to indicate that it had produced subjective symptoms.

Appendices Epiploicæ as Foreign Bodies

CASE L (A210428).—Mrs. C. B., aged forty-two years, was examined October 8, 1917. The patient who was very obese had had six operations for appendicitis, uterine prolapse, and postoperative hernia, the last one six years ago. For the past four years there had been more or less lower abdominal pain which she thought due to adhesions. She presented herself for the repair of the postoperative hernia.

November 28, 1917, a large postoperative hernia was repaired. A tumor was found free in the pelvis, 4 by 3 by 3 cm. This proved to be a sac containing degenerated fat, probably an appendix epiploica which had become twisted from its attachment to the large bowel.

Incarceration of Appendices Epiploicæ in Hernial Sacs

CASE LI (172141).—G. G. B., a male, sixty-three years of age, was examined September 12, 1916. Nine months previously the patient had developed soreness in the left lower abdomen with the formation of a

mass which had persisted and the soreness had been aggravated by exertion. There were no other subjective symptoms. The patient was obese. On physical examination a small mass was palpable above the left internal inguinal ring and there was, separate from this, a left inguinal hernia. Urinalysis, blood, and X-ray examination of the colon were negative.

September 18, 1916, abdominal exploration was done through a low left rectus incision. No disease other than the tumor mass was revealed. This apparently came and went as the sigmoid which was held tightly against the left internal inguinal ring became blocked. A large incarcerated mass of omentum which was undergoing necrosis was found in the hernial sac, dissecting its way between the muscles and fascia. Adherent appendices epiploicæ of the sigmoid were also contained in the hernial sac, which held the sigmoid in a fixed position. The omentum was divided and the sigmoid separated from its adhesions. The hernial sac and contents were removed and the internal ring closed with mattress sutures.

CASE LII (A186645).—A male, aged fifty-one years, was examined February 24, 1917. The patient had been perfectly well until one week previously when, after lifting a heavy load, he experienced pain in the left groin and a swelling formed which had remained painful and had caused some nausea. Physical examination was practically negative except for a firm irreducible mass $1\frac{1}{2}$ inches by 1 inch in the region of the left external inguinal ring.

At operation March 13, 1917, an incarcerated appendix epiploica of the sigmoid was found in a left inguinal hernia. The appendix epiploica was excised and the hernia repaired.

APPENDIX EPIPLOICA PRODUCING INTESTINAL OBSTRUCTION

CASE LIII (A49009).—C. G. G., a male, aged fifty-seven years, was examined February 8, 1911. The patient's health was in fair condition until eight months previous to examination, when he had had a sudden attack of pain in the left lower abdomen, with much distention followed by soreness for six or seven days. A month later he had a similar spell. Three months later he had a very severe attack with symptoms of intestinal obstruction for seven days. He was in bed fourteen days, during which time there was much pain, tenderness and rigidity in the region of the umbilicus, with apparent obstruction in the left lower abdomen. Morphia and chloroform were used to control the pain. The last severe attack was eight weeks before, but the lower abdominal soreness persisted up to the time of examination. There was never any blood in the stool. The patient had lost about 30 pounds in weight; otherwise the general physical examination was negative. A diagnosis of chronic intestinal obstruction, with possible carcinoma of the sigmoid, was made.

Operation February 13, 1911, revealed obstruction of the sigmoid by a band due to a long appendix epiploica which was adherent across the top of the sigmoid near its middle. Over this a loop of the sigmoid had dropped causing a rather tight obstruction. The band was divided and appendectomy done for acute appendicitis.

TORSION OF APPENDICES EPIPLOICÆ

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LEGG'S DISEASE

ARTHRITIS DEFORMANS JUVENILIS: OSTEOCHONDRITIS DEFORMANS JUVENILIS:
"PERTHES'S" DISEASE

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OF SAN FRANCISCO

UNDER the title, "An Obscure Affection of the Hip Joint," Arthur T. Legg, of Boston, reported before the American Orthopædic Association, in 1909, a series of observations on five cases of a disease not previously identified, and published his paper in 1910.¹ His report was brief, accurate and scientific. Very little definite has since been added to it.

In 1910, Perthes,² of Tübingen, reported cases of the same disease, without recognizing their nature, publishing them as cases of Arthritis Deformans Juvenilis; that is, as cases of "arthritis deformans" in the young. In 1913 Perthes recognized that the disease bore little resemblance to what the Germans call arthritis deformans. Evidently he overlooked Legg's original paper. He excised from one patient a piece of the synovial membrane, and a piece of the head of the femur. The synovial membrane showed no sign of inflammation; therefore Perthes rightly concluded that the disease was not an arthritis. Neither the bone nor the cartilage showed evidence of inflammation, yet Perthes calls his "new" disease Osteochondritis Deformans Juvenilis.³

Since 1913 many others in this country and in Germany have reported cases of the disease, and gradually the name Perthes's Disease has been adopted for it. A half-hearted attempt has been made in America to give Legg due credit, but I have never seen his name mentioned in the German periodicals. As the American Orthopædic Association is not a secret society, nor the *Boston Medical and Surgical Journal* an obscure periodical, one notes with amusement or irritation the recurrence of an oft-observed phenomenon.

Following is a report of five cases, with an abstract of their histories. Most of them were thoroughly worked up, and any possible source of infection was sought for.

CASE I.—F. A., six years old, December 31, 1914. Pain in right knee, limp. Abduction markedly limited. Positive von Pirquet test. Treatment: Short plaster spica for about six months. Since then no

¹ *Boston Medical and Surgical Journal*, 1910, clxii, 202.

² Perthes, "Deutsche Zeitschrift für Chirurgie," 1910, cvii, 111.

³ Perthes: *Archiv f. klinische Chirurgie*, 1913, ci, 779. "Die Synovialis . . . zeigt sich völlig unverändert . . . Microscopisch zeigt der Gelenkknorpel das Bild des hyalinen Knorpels mit überall guter Kernfärbung. In dem darunter liegenden Knochen fallen zahlreiche Knorpelinseln auf, mit unregelmässig zackiger Begrenzung. Die grösste dieser Knorpelinseln liegt dicht unter dem Gelenkknorpel und ist mit dieser durch einen dünnen Stiel verbunden. . . . In den Zwischenräumen zwischen den Knorpelinseln finden sich normale Knochenbälkchen und von diesen eingeschlossen auffallend weite, mit Fettmark ausgefüllte Markräume. Zeichen entzündlicher Infiltration finden sich nicht."

treatment. Patient disappeared, and was brought for examination by request in December, 1918. He is said to limp slightly when he is tired. He walks well but has a slight exaggeration of his lumbar lordosis. His trochanter is prominent. Abduction is slightly limited. Flexion limited to 90° .

CASE II.—C. I., thirteen years old, May 5, 1914. Pain in right hip following a fall five months previously. Ecchymosis was present at that time and swelling. The boy has limped ever since. Examination showed three-quarters of a centimetre lengthening, and a positive Ely's sign on both sides. The incisors were irregular, without enamel near the point, and with "shoulders." The von Pirquet test was positive, the Wassermann test negative. The boy was undersized and underdeveloped. (Under thyroid extract he grew one inch in five weeks.) Treatment: Plaster spicas. After treatment for eight months the right lower extremity was one and one-half centimetres longer than the other. The patient had also antiluetic treatment for a long time. There was no note of pain on the left side, but involvement of the left hip was discovered in April, 1915, and shortly after that the adductors were stretched under ether and a double spica was applied in abduction. June, 1915: "Cannot move right hip at all." The plaster was removed in February, 1916. Brought by request November, 1918. No limp is present. The boy is said to walk and play normally. The trochanters are prominent. The lower extremities are of equal length. The right hip is limited in flexion to a right angle, decidedly limited in abduction, and slightly limited in extension. The left is a trifle limited in flexion, and somewhat in abduction. In spite of the comparatively good functional result, the skiagram shows marked double coxa vara, and great distortion of the head and neck. It is seen, from a study of the skiagrams, that nothing characteristic is present in the left hip. A positive diagnosis of Legg's disease on that side cannot be made, and yet the outcome is practically the same.

CASE III.—W. L., aged eight years, April 28, 1917. Pain and limp for two or three weeks with history of injury six months previously. This was followed by complete recovery.¹ Three months previous pain in left thigh and limp, continuing to date. Examination showed a limp. The hip is in slight flexion and abduction. Extension, adduction and especially abduction limited. Flexion is free. Treatment: Short plaster spicas for about a year, then a brace. Now apparently well, December, 1918, with a free range of motion, except abduction, which is slightly limited.

CASE IV.—B. P., aged nine years, April 5, 1916. Pain in right shin following injury to knee four months ago while playing top.² Restriction of motion at extremes in all directions. Limp. Negative Wassermann. The tonsils contained pus, and were removed. Treatment: Short spicas from May 2, 1916, to April 5, 1917. December, 1918: No limp, trochanter prominent. Hip goes into abduction on forced flexion and abduction is perhaps a trifle limited. Otherwise complete recovery.

¹ Probably the boy sprained his joint already damaged by the characteristic changes, and his sprain grew well.

² Observe the forced sequence of cause and effect.

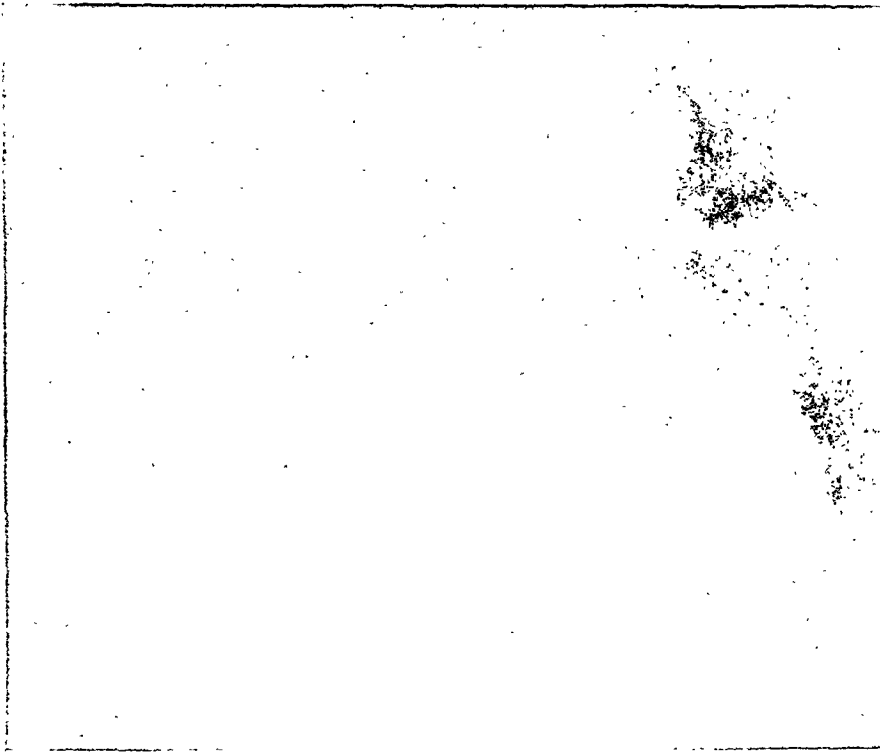


FIG. 1.—Case I. Final skiagram, December, 1918. The plate taken at the first examination is lost. Note flattening of head and lateral displacement, and decrease in density of upper and lateral part of neck. Thickening of neck.



FIG. 2.—Case II. Skiagram taken at first examination, May, 1914. Flattening and irregularity of head, irregularity and lack of definition of epiphyseal line. Irregularity of upper border of neck.



FIG. 3.—Case II. January, 1915. Increased irregularity of head, with segmentation and lateral displacement. Increase in density of neck and of intertrochanteric part of femur.



FIG. 4.—Case II. April, 1915. Outline of head is smoother, but head is segmented, and its lateral displacement is more marked. Scarcely anything is to be seen in the left hip.

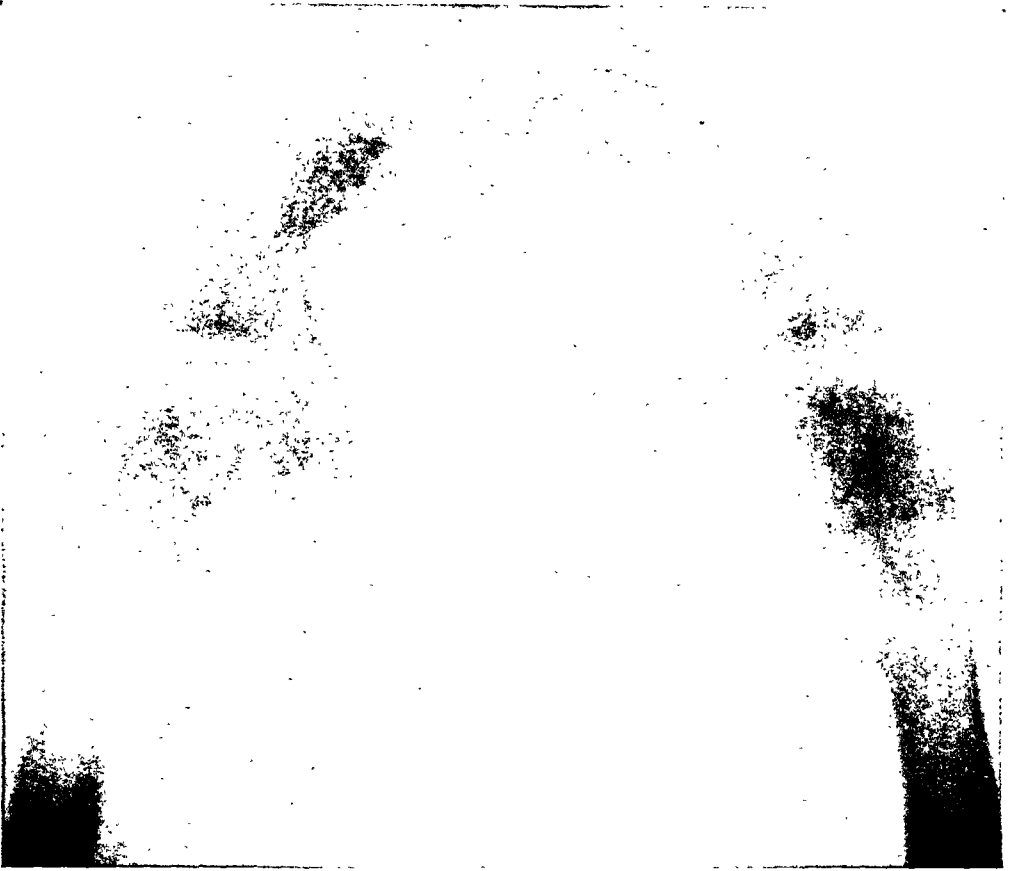


FIG. 5.—Case II. February, 1916. Irregularity of acetabulum on right side. Head of femur flattened, broadened, and irregular in outline. Neck short, thick, and dense. Still nothing characteristic on left.



FIG. 6.—Case II. November, 1918. In right hip the disease has reached its typical end in spite of treatment. On the left, though no definite picture of Legg's disease has been present, it is indicated by the well-marked coxa vara.

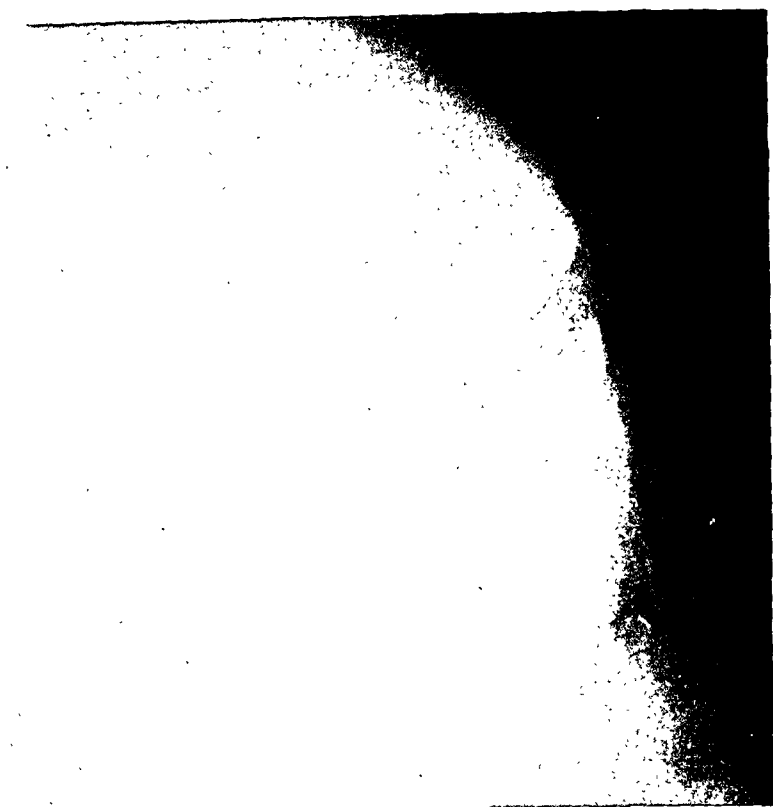


FIG. 7.—Case III. April, 1917. Flattening of head, and irregularity of ossification. Irregularity of epiphyseal line.

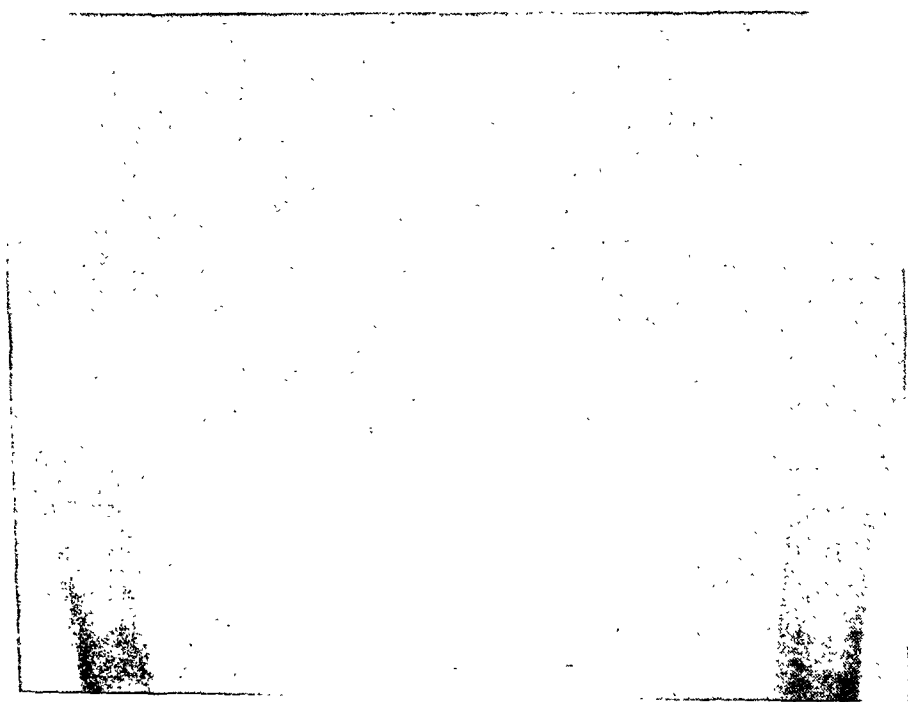


FIG. 8.—Case III. December, 1917. Little change in head of bone. Area of decreased density in upper, medial part of neck.

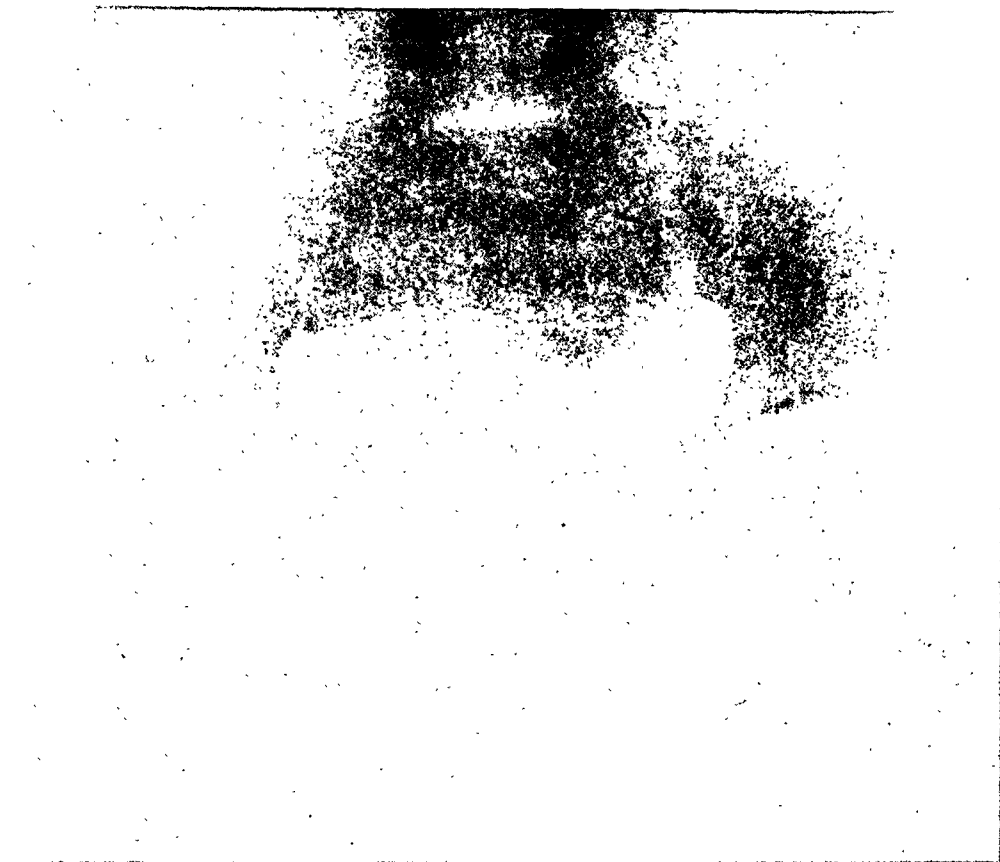


FIG. 9.—Case III. May, 1918. More extensive irregularity of the head of the bone. If this irregularity represented actual bone destruction, the stump of the neck would be applied close to the acetabulum, instead of being at a distance from it.



FIG. 10.—Case III. October, 1918. The head is becoming more uniform in texture and outline. This could not be, if it had been destroyed.

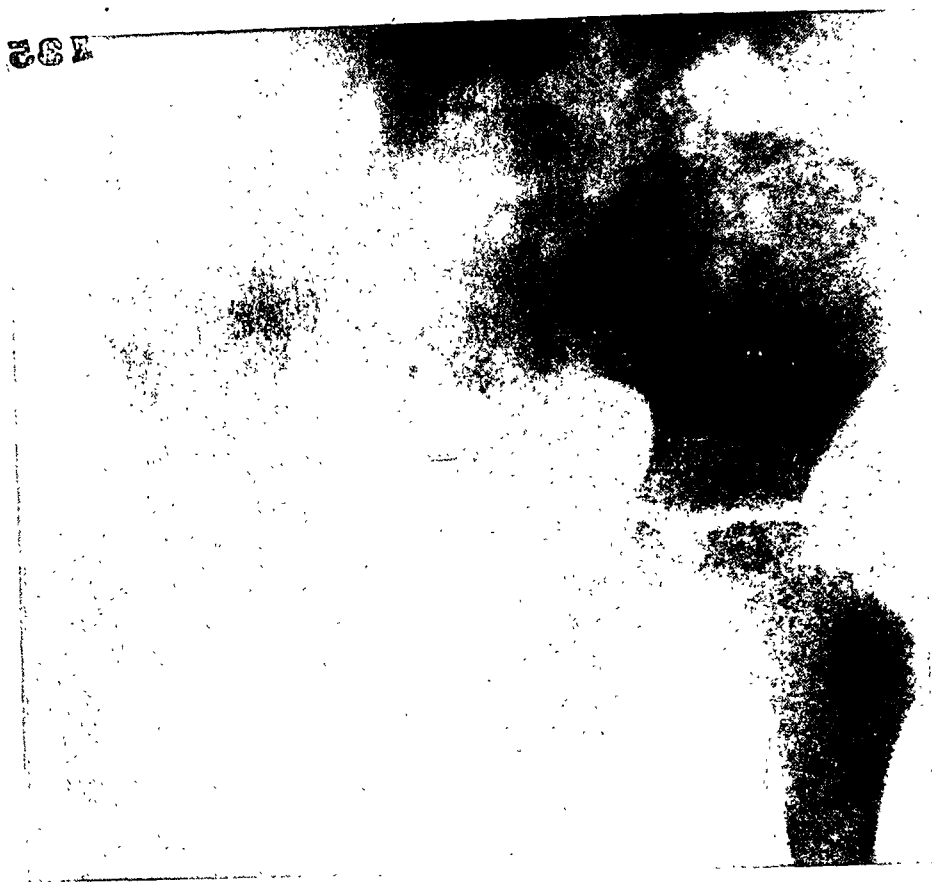


FIG. 11.—Case IV. April, 1916. Flattening and slight irregularity of the head, with some widening and irregularity of ossification of proximal part of the neck of the femur, in a sort of band near the epiphyseal line.



FIG. 12.—Case IV. December, 1917. Marked segmentation of head, with obliteration of any formal epiphyseal line. Irregular ossification of neck in the vicinity. Thickening of neck.

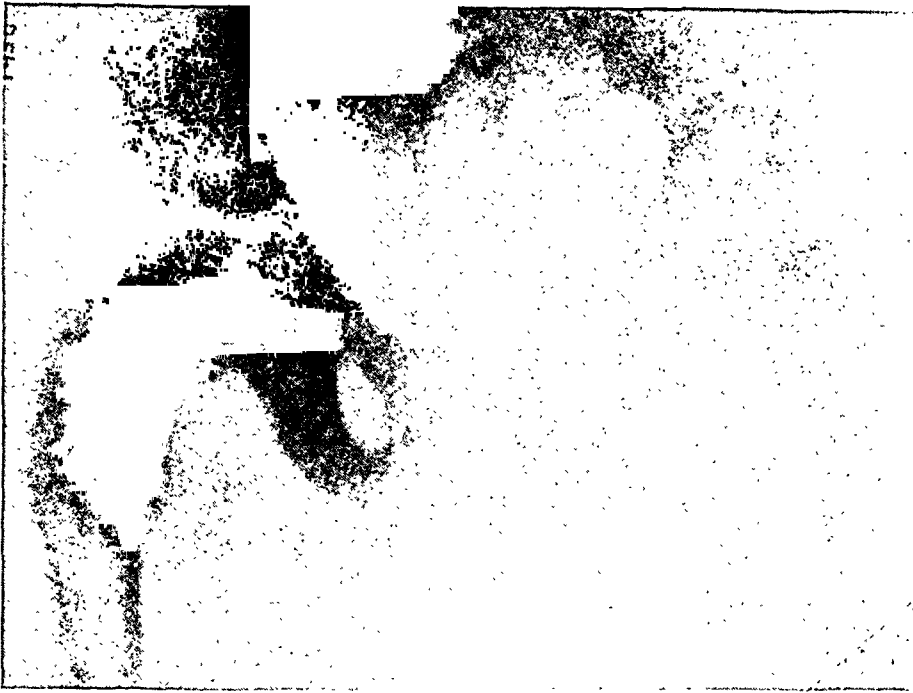


FIG. 13.—Case IV. November, 1918. Wider separation of head fragments. Increase of width of neck. Slight decrease in irregularity of ossification of neck. With this striking picture the hip is practically well.

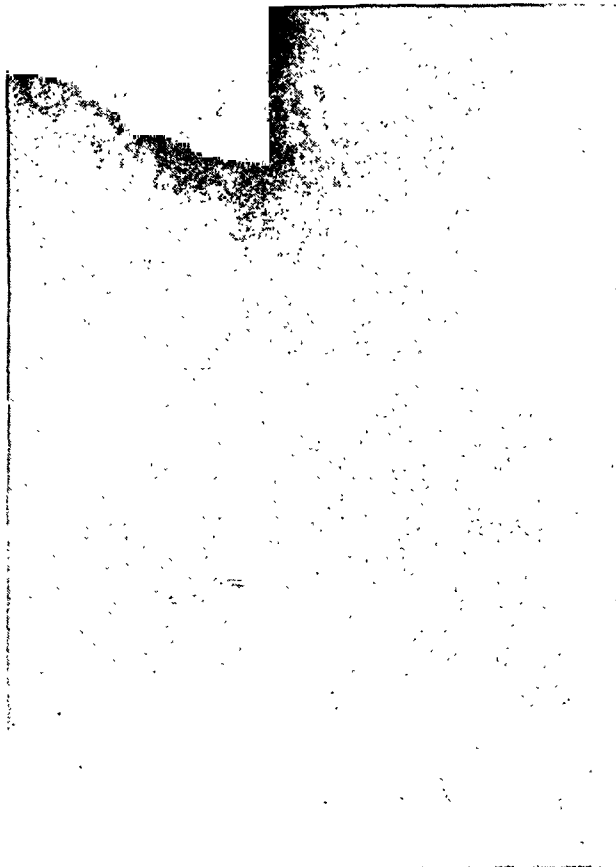


FIG. 14.—Case V. May, 1917. Flattening, broadening, irregularity and segmentation of head, with lateral displacement. Thickening of neck.

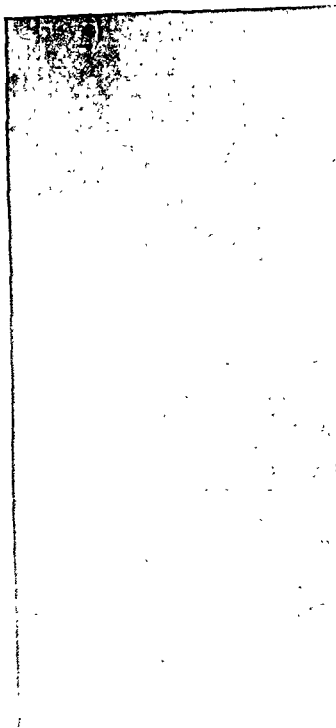


FIG. 15.—Case V. February, 1918. Little change. Neck a trifle thicker.

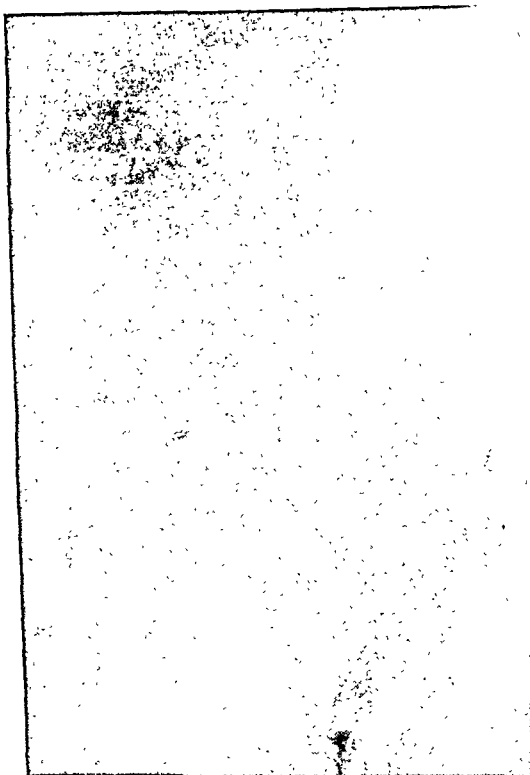


FIG. 16.—Case V. September, 1918. Some increase in density of bone.

LEGG'S DISEASE

CASE V.—A. R., aged eight and a half years, November 17, 1915. Complaint: Limp, and pain in groin. "Probably negative" von Pirquet. Examination showed slight limp. Abduction practically nil. This and the preceding case had the peculiar sign of abduction in flexion of the hip. One-fourth inch shortening. Tonsils showed pus in crypts and were removed. Short spicas from April 7, 1915, to June 13, 1917. December, 1918: No limp, no deformity. Slight limitation of abduction and adduction. Less than one-half inch shortening.

Until the opportunity is afforded of examining some specimens in the laboratory, we shall lack definite knowledge of the disease, but the following facts, theories, and conclusions may be interesting.

Legg's disease is an error in development of the whole upper epiphysis of the femur—trochanter, neck and head. In this the acetabulum sometimes shares. It affects chiefly the head and the proximal lateral portion of the neck, and the cartilage between them. The great trochanter may or may not be involved.

It possesses a strong congenital element. It is first observed between the ages of five and ten.¹ It is thought to affect boys more often than girls, in the proportion of 4-1; but, counting the cases observed with congenital hip dislocation, the disproportion is probably not marked.

It is often seen after reduction of congenital hip dislocation, occasionally on the sound side.²

It is frequently bilateral, with symptoms only on one side.

In two cases a growth of staphylococcus has been recovered at operation from a softened area in the neck. One case showed a "necrotic" area, the other a "grayish" condition of the marrow. The pathological reports in these cases leave much to be desired. No evidence of an arthritis ever has been adduced.

It is hard to explain its causation by circulatory disturbances. Trauma probably does not cause it, but simply acts by spraining the distorted joint. Trauma often causes the symptoms but not the disease. Witness the frequent bilateral nature and the fact that almost invariably the X-rays show the complete and definite picture at the first examination. Then, in spite of treatment, or without treatment, the affection pursues a definite course, which no trauma would explain. This course may be modified by correct treatment, and the resulting deformity (coxa vara) avoided.

The areas of "destruction" (so-called), shown by X-rays, in the head, may possibly be areas of unossified cartilage. It is not likely that a destructive inflammation in the marrow of the head and neck could exist without symptoms, and without causing an arthritis, except as a great rarity. These irregular patches are standard in Legg's disease, occur with or without symptoms, and are present after healing apparently has occurred.

The typical Röntgen picture consists in: (1) A flattening, broadening,

¹ In this connection the fact that the patient in Case 2 was markedly underdeveloped is extremely interesting. At 13 years he appeared to be about 8.

² Perthes, Brandes.

and sometimes an apparent displacement of the epiphysis laterally, with one or more divisions of it and irregularity of ossification. (2) An irregularity or even segmentation of the cartilage between it and the neck. (3) Loss of bony structure in the neck, especially of its proximal and lateral part.¹ (4) Irregularity in contour of the upper part of the femur neck. (5) Distortion of the head. (6) Enlargement of the trochanter (occasionally). (7) Irregularity of the acetabulum—not characteristic.

The astounding difference between the marked changes in the X-ray picture and the comparative insignificance of the symptoms and physical signs is characteristic.

The interesting query presents itself: Are all these changes due to some one special cause, or is one of them the essential change, and all the other changes its result?

The later picture shows a short thick neck, often coxa vara, and a distorted head. The chief symptoms, when symptoms are present, are limp and pain. Examination shows the limp, a prominent trochanter, and limitation, especially of abduction. Other motions may or may not be limited. A peculiar sign is the abduction at the hip when flexion is forced.

The affection seems to run its course in two or three years. Its most active period is one year. Even after all symptoms have subsided and a cure evidently has been obtained the X-ray may show an alarming picture.

Fibrous or bony union of the joint never occurs. The restriction of motion is mechanical.

In the past, Legg's disease often has been mistaken for tuberculosis, and cases of it have been quoted to swell the list of cures by some favorite treatment. The diagnosis as a rule is not difficult. Tuberculosis has more pain, more muscular spasm, greater restriction of motion and greater muscular atrophy. It shows radiographically more involvement on the shaft side of the epiphysial line and less in the head of the bone. It has not the same disproportion between the X-ray picture and the symptoms and physical signs.

As infection cannot be ruled out, any possible focus of infection in the body may be removed.

A good treatment consists in reduction of the deformity, if necessary under anæsthetic, and the immobilization of the fully abducted hip in a short plaster spica until the process has run its course and the neck has firmly solidified. Crushing of the head is not to be feared.

Finally, as Legg described Perthes's disease three years before Perthes, the justice of calling it Legg's disease seems sure.

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NOTES ON THE USE OF RUBBER GLOVES IN SURGICAL OPERATIONS*

BY ROBERT T. MORRIS, M.D.

OF NEW YORK

At the present time the employment of rubber gloves in surgery belongs practically to a settled question. Let us for a moment take up for examination several features of the subject—which are now covered by a blanket of accepted custom. In my opinion the development of the rubber glove in its application to practical work has represented one of the most important advances ever made in the field of surgery. Full credit is due the surgeons who have fought their way with the merits of the rubber glove against the forces of the opposition—some of which forces had genuine purpose; other and larger ones related perhaps to inertia and indifference on the part of a profession which needed to be led on with determination to correct methods. Because of the psychology of the situation we sometimes find in our profession that, by the time there is full acceptance of or agreement upon any one subject, it is out of date. At the time when I stood openly against the employment of rubber gloves, thick and ill-fitting gloves were the only ones obtainable. I saw much bungling work done by my assistants and by skilled surgeons. I feared for the future of surgery with a lost *tactus eruditus*—that sense of touch lauded since the earliest days in the history of medicine and estimated at its true value by skilled surgeons at the time of the introduction of the rubber glove.

What are the basic principles involved? Rubber gloves can be sterilized readily and completely. Well prepared hands commonly carry not only a few free bacteria but also nests of bacteria, hidden in the epithelium, which may be liberated when the hands become softened with blood serum. The surgeon working with rubber gloves requires on the whole rather longer incisions than those required by the surgeon working with the sense of touch; and this brings us to the question as to whether the bacteria carried into the wound by the surgeon's hands are more harmful than those which fall in from the air during the course of an operation. Petri plates carrying culture media and exposed in the best of operating rooms become infected from the air after fifteen minutes' exposure. On the other hand, we know that fresh blood serum exerts an inhibitory influence upon any bacteria which are carried into the wound either by the surgeon's hands or from the air.

At the time when I took a decided stand against the indiscriminate

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RUBBER GLOVES IN SURGICAL OPERATIONS

employment of rubber gloves (please place emphasis upon my choice of the word "indiscriminate"), I did not wish to be mistaken or to hold to an idea which might be injurious to any of my patients. At that time inquiry was made in reference to this point at various hospitals in which I had occasion to operate. According to the information then received the infections in my own cases were less than in those in the practice of some surgeons who used rubber gloves at all times.

An arrangement was concluded for an expert in tactile sense to make accurate tests of this feature of the situation with several surgeons. The thinnest and best of rubber gloves were employed and the experimenter found that the sense of touch was regularly diminished in all of the men tested, although two of those who wore rubber gloves had developed their sense of touch while wearing gloves almost to a normal degree. One of these men was a surgeon of exceptional skill; the other, a physician not belonging properly among surgeons, but a specialist in children's diseases. At the time when my opposition to the indiscriminate use of rubber gloves was held to be erratic, I was interested in formulating the principles of the Fourth or Physiologic Era in Surgery in which we are to conserve the natural resistance of the patient in every possible way in order that he may better develop his opsonins and phagocytes immediately after the operation. This included among other points the idea of rapid work through comparatively short incisions. The employment of rubber gloves related more particularly to the Third or Pathologic Era in Surgery in which the surgeon was to employ all of his resources for keeping bacteria out of wounds and for destroying those which had entered the wound. Certain principles relating to both the third and fourth eras of surgery need to be harmonized at this stage in the evolution of our subject.

When should rubber gloves be employed? In practically all routine work in almost all departments of surgery. We then elaborate and classify cases in such a way as to ask in which group of cases the employment of rubber gloves should be obligatory; in what class of cases they are unnecessary, and may or may not be used according to the wish of the surgeon, the matter being irrelative to the patient's interest; lastly, in what group of cases the employment of rubber gloves would lessen somewhat the patient's chances for receiving the highest degree of skilled attention.

The employment of rubber gloves should be obligatory in practically all work belonging to general surgery and obstetrics—a field so large that mere reference to the point is all that is required. The group of cases in which rubber gloves may or may not be used would include several quite separate fields of surgery. There are certain areas of the body like the oral and anal regions, for example, which we call protected areas in the sense that they are so constantly exposed to bacterial invasion that nature appears to have established special guards

against the entrance of infection into the tissues. These areas cannot be thoroughly sterilized by any of the methods at our disposal, and primary union is the rule after operation in cases in which incomplete methods of asepsis have been employed by the surgeon; or, if not primary union, a benign tendency toward repair. The perineal region is included in this area, and a surgeon working without gloves may sometimes repair a torn perineum particularly well and speedily when depending upon his best sense of touch. We have come to know that the peritoneum under ordinary circumstances is remarkably resistant against bacterial invasion, and that Tait working without asepsis or antiseptics in his day secured better results than were secured by his rivals advocating the use of asepsis and antiseptics. Tait worked with great rapidity through short incisions, aided by the sense of touch, and conserved the natural resources of his patients. Peritoneal adhesions require for their separation a particularly nice sense of touch and delicate manipulation of viscera. To quote Dr. T. L. Bennett, the expert anæsthetist, "the best surgeon is the surgeon who acts all the while as though he were afraid of waking the patient up." The employment of rubber gloves in peritoneal adhesion work commonly requires a much larger incision and more work by sight than would be required by the skilled surgeon depending upon his sense of touch. In perforating ulcer of the stomach or in typhoid perforations the surgeon working without gloves may insert his drains so quickly that the entire operation may be performed in some cases in less than five minutes—a life-saving step frequently resorted to and followed by better technical surgery later if necessary. The presence of calculi in the common bile duct, in the pancreatic duct, or in the ureter, sometimes requires the last degree of fineness of tactile sense in order to avoid the more extensive surgery which would otherwise be in order. With one finger of the surgeon inserted through the peritoneal abdominal wall, pressing a small ureteral calculus firmly against the muscular abdominal wall, the operator may employ his other hand for approaching the calculus from some external point so rapidly and accurately that the calculus may be removed in a very few minutes of operative work.

In many cases of chronic appendicitis with old adhesions, and in many cases of acute appendicitis with extensive new adhesions, the surgeon's sense of touch may be employed at its very best for avoiding more extensive surgery which would belong to work by sight. This is true also in cases of pelvic infections; and it would appear almost an absurdity for a surgeon to employ rubber gloves with the idea of avoiding infection, in cases where infection is already present to a high degree. Protection of the surgeon is perhaps the only valid argument in favor of the employment of gloves in such cases.

Under modern methods of treatment the pleura is found to be nearly as resistant to infection as is the peritoneum; and one may sometimes

RUBBER GLOVES IN SURGICAL OPERATIONS

open the chest wall, allowing the lung to collapse, and with the ungloved hand find a missile or enlarged glands or a small lung abscess with a rapidity eminently desirable when we are working without the aid of the pneumatic cabinet.

In cases of malignant disease of almost any part of the body, the malignant disease has called out such a protective force in the surrounding tissues of the patient that primary union often occurs—as in such cases in olden times when the surgeons washed their hands after operations instead of before operations.

In some of the tissues which are not especially protected in any way, one sometimes works to advantage by the sense of touch so rapidly that fewer bacteria are carried in by the hands than would fall in from the air. The operation for loose kidney, for example, may frequently be completed in ten minutes of operative work between the first incision and the last suture. This, however, is a special occasion and would not refer to general application of the principle which includes the employment of rubber gloves.

In the group of cases in which the use of rubber gloves actually lessens the efficiency of the surgeon to a degree detrimental to the interests of the patient, we think at once of certain operations upon the eye and in nose and throat work.

As a final statement I would express the opinion that the employment of rubber gloves in routine work for practically all surgery represents one of the most important advances that has been made in the surgery of to-day. A few situations allow the expert surgeon to do better work without gloves.

In hospital rules making the use of rubber gloves obligatory it may be well to insert a clause to the effect that when a surgeon does not use rubber gloves in any given case he is to make a record of his reasons for the omission.

TRANSACTIONS OF THE NEW YORK SURGICAL SOCIETY

Stated Meeting, held November 13, 1918

DR. WILLY MEYER in the Chair

TUBERCULOSIS OF THE SPLEEN

DR. FORBES HAWKES presented a patient who had been previously shown before the New York Surgical Society on October 26, 1910, with tuberculosis of the spleen. He was eight years old at that time and had been operated upon for a large adherent spleen. Sections removed from the spleen had shown tuberculosis. He had made an excellent recovery—the spleen had diminished in size, and the boy had been in perfect health since then. When shown on November 13, 1918, his spleen was not palpable. His operative scar was solid. He had been at work during the period of the war in a tool factory, doing overtime work as well.

DR. WILLY MEYER considered it very interesting that a tuberculosis of the spleen was affected by laparotomy in the same favorable way as are so many cases of tuberculous peritonitis. The young man's good condition after a number of years certainly points in this direction.

BILIARY CIRRHOSIS AND CHRONIC PANCREATITIS

DR. A. O. WHIPPLE presented a woman, sixty years of age, married, who, on admission to Presbyterian Hospital on June 20, 1918, gave the following history: Persistent jaundice; swelling of the abdomen. Dates back one year. Following an indiscretion in diet of rich food, she had an attack of indigestion characterized by severe dull pain in the epigastrium, radiating to the back. The severe pain lasted two days and she noted that her skin and scleræ were becoming jaundiced. Since then she has had recurrent attacks of pain in the same region, radiating to the back, made worse by eating too much and by taking fats or coffee. At times the pain was relieved only by morphine. The jaundice has remained fairly constant, gradually changing from yellow to a bronze color. Stools have been clay colored, though at times they show a slight yellowish tinge. There has been great pruritus. During the past twelve months she has lost over fifty pounds and during the past three months there has been marked loss of strength and appetite.

For many years she had had mild attacks of indigestion with bloated feeling and eructations of gas. No history of typhoid. One pregnancy thirty-eight years ago. Patient was seen three months before operation,

BILIARY CIRRHOSIS AND CHRONIC PANCREATITIS

when she came to the hospital for observation and study, where she remained for four days. At that time, which was in April, 1918, she showed a deep bronze color; she was very nervous; pulse was slow; no evidence of hyperthyroidism; the abdomen was flat with a prominence in the right upper quadrant and epigastrium. This corresponded roughly to a mass which extended 4 cm. below the costal margin, moved on inspiration; was slightly tender; surface was smooth. It was considered to be the liver. Wassermann was negative; her blood began to clot at eleven minutes. There was a slight trace of bile in the stool. X-ray examination showed a large oval shadow situated just to the right of and opposite the body of the second and third lumbar vertebræ. This was diagnosed a gall-stone. The diagnosis was made of *chronic cholecystitis, cholelithiasis, with stone in common duct*. Patient decided to defer operation and was observed several times during three months. Her condition did not improve and she lost more weight and developed ascites.

At the time of her second admission, the liver was found 6 cm. below the costal margin, it was tender; patient was deeply bronzed, showed only a slight trace of bile in the stools and her blood began to clot at thirteen minutes. A preliminary infusion (300 c.c.) of a 0.2 per cent. solution of calcium lactate in normal saline was given. Urinalysis did not show at any time glycosuria.

Operation (June 22, 1918).—An J-shaped incision gave good exposure and disclosed the following findings: About two gallons of free fluid were aspirated, bile-tinged in color. The liver was enlarged down to the level of the umbilicus. The surface was smooth, there were no nodules and it had the appearance of a cirrhotic liver of the hypertrophic type. A mass was found on the under surface of the right lobe densely adherent to the stomach and duodenum. This mass was found to consist of the gall-bladder, surrounded by omentum. The tip of the gall-bladder was white and nodular, resembling carcinoma, but a section from the attached omentum and from the wall of the gall-bladder made at the operation by frozen method, failed to show carcinoma. The gall-bladder when opened showed a dense, thick wall and the lumen was occupied by a very large gall-stone, measuring 5 by 3 by 3 cm. There was some pus about this stone and the walls of the gall-bladder were markedly degenerated, in places showing actual calcification. Cystic duct was found to be patent, a clear golden bile coming away after removing the stone. The pancreas was not uniformly enlarged, showed a marked induration about the common duct. Because of the patient's jaundice and the very dense character of the adhesions between the gall-bladder, stomach and duodenum, a cholecystectomy was not attempted, although it was considered the operation of choice. Instead, cholecystostomy was done. Because of the dense adhesions about the common duct and the hemorrhage resulting from attempts to open it,

choledochotomy was not accomplished. Drainage aside from the cholecystostomy tube consisted of a cigarette drain to the bottom of Morrison's pouch. The patient's condition was fairly good—pulse 86 at the close of the operation. There was no tendency whatsoever to hemorrhage, blood clotting firmly in the wound.

Patient showed no marked reaction following operation; distention was easily controlled with colon irrigations; she drained bile freely from 700 to 1000 c.c. every day. The tube was left in place for twelve days, when it was extruded. After that, biliary fistula continued throughout the patient's stay in the hospital of thirty-seven days. Stools remained acholic during this time. The patient showed a loss of appetite and considerable asthenia during the last two weeks of her stay in the hospital. By means of tonic treatment and the administration of pancreatic extract and ox-gall, she was able to digest her food fairly well. After leaving the hospital, she continued to have a fistula with clay-colored stools for ten days, that is, for about seven weeks after operation. She then noted that the discharge from the fistula suddenly ceased and she began to have colored normal movements. Fistula has remained closed and the patient has continued to show marked improvement. Examination two months after operation showed an abdomen normal in contour, firm, linear scar, the liver edge had receded to within 2 cm. of the costal margin, there was no fluid and no masses nor tenderness.

Patient when examined six months after operation shows good color, no jaundice in skin or scleræ. Scar linear, firm. No fistula. She has gained twenty-five pounds in weight since operation.

DR. ALFRED S. TAYLOR said that when a patient had suffered the drainage of bile outside the body for a long period he became thin and weak. He had had that experience with a case this summer after long drainage of bile. Dr. John Gerster had had a similar case where he followed the method of taking the drained bile and putting it back into the patient's stomach. He suggested the application of this method to Dr. Taylor's patient. Her own bile could not be used satisfactorily because of the presence of mixed infection; so clear bile was obtained from another patient and from half a pint to a pint per day was administered through a stomach tube. After a short time she preferred to drink the bile rather than have the stomach tube passed. Almost from the start there was a marked change in the condition of the patient; she improved in strength and developed an appetite, and was able to take food with comfort that she had not been able to retain for a considerable period previously. Under this treatment she progressed steadily, and finally was able to leave the hospital in good condition.

DR. WILLY MEYER stated that in a case of biliary trouble, under his care in the course of last winter, following cholecystectomy there was prolonged bile drainage. About ten weeks later a secondary operation for the biliary fistula was done. Inasmuch as there had not been the slight-

est jaundice, it did not seem necessary to make a coagulation test. But from six to seven days after the operation the patient began to bleed; there was considerable parenchymatous oozing. Blood transfusion succeeded in stopping the hemorrhage.

Doctor Meyer stated that he had no experience in these cases with calcium lactate; he treated patients with chronic jaundice and delayed coagulation for years with preliminary injections of human blood serum in large amounts, within two or three days before operation, and had yet to see a case thus treated that had begun to bleed. So far he had considered this the only safe method at our disposal. It is most interesting to know that there is a second one available. He would like to know whether Doctor Whipple had treated any other than patients suffering from biliary trouble with this injection.

The patient just referred to developed a duodenal fistula about twelve days after the operation. Further surgical work was out of the question. By allowing an extra long duodenal tube to slip down into the upper part of the jejunum as far as possible and keeping the patient's mouth absolutely dry, but feeding him regularly through this tube, the fistula closed spontaneously. This tube was also used for reintroducing into the jejunum the bile which ran out from the fistula in large volume. This also changed the patient's general condition very much. Later on she learned to put the bile into her stomach. It certainly is very desirable not to have the patient lose the bile.

To him it appeared very wise on the part of Doctor Whipple to have made frozen sections of the gall-bladder fundus during the operation. The result of the immediate examination in this case enabled him to retain the gall-bladder for prolonged drainage. With the gall-bladder in place we can arrange for drainage just as long as desired. The time of directly draining the bile-ducts is more limited. Yet, only prolonged drainage can cure these cases.

DOCTOR WHIPPLE stated that he failed to mention the fact that the patient's blood was tested the morning before the operation and the clotting time was seven minutes. The reason why he was using calcium lactate intravenously for preventing hemorrhage was because of the experience he had had with a patient whom he had presented at the Society last spring. This man had very much the same lesion that the patient whom he presented this evening showed. His clotting time before the operation was thirteen minutes. He was given a preliminary transfusion of Group 2 blood from a member of the interne staff. He stood the operation very well, but six days later began to bleed from the wound. Notwithstanding a second transfusion and administration of bile by mouth he continued to bleed and his condition became very critical. In desperation it was decided to try calcium lactate by the blood stream, with the idea of introducing calcium more directly into the patient's tissues.

The intravenous dose was found to be 5-10 grains, given as a 0.2 per cent. solution in normal salt solution. This is the dose given by Bastedo in his "Pharmacology." The effect of the medication was very graphically demonstrated, for the infusion was given while the wound was dressed and the wound which at the beginning of the dressing showed no blood coagulation whatsoever, in twelve minutes showed a firm clot in the wound with complete stoppage of the oozing.

Since that experience the calcium lactate infusion has been tried in eight cases of deep jaundice. In every case the clotting time has been reduced by one-half or more.

In regard to the complication that Doctor Taylor mentioned: Several such cases have been observed at the Presbyterian Hospital. In these cases the administration of bile, preferably the patient's own, either by mouth or by gavage, has improved the digestion of the patients in a remarkable manner. This asthenia and loss of weight is a very serious problem in a patient who has been chronically ill for weeks and has undergone a severe operation.

In closing Doctor Whipple said that the severe oozing under discussion was not dependent upon bile in the tissues, but rather to an absence of bile salts in the alimentary tract, for the same bleeding may occur in a patient with a biliary fistula without a trace of jaundice, in fact, the oozing may be more persistent in such a case than in the deeply jaundiced.

NON-PARASITIC CYSTS OF THE SPLEEN.

DR. ADRIAN V. S. LAMBERT read a paper with the above title, for which see p. 15.

EDITORIAL COMMENT

JANSSEN ON CRANIOPLASTY: ITS INDICATIONS AND ITS TECHNIC

IN the second volume of "Travaux Scientifiques," from the Ambulance de l'Océan at La Panne, Belgium, Dr. CHARLES JANSSEN discusses the indications and technic of cranioplasty. He says: Brain wounds healed after operation are not guaranteed against later complications. Much has been said about the late reappearance of a cerebral infection which had apparently been overcome. Recent studies seem to show that the frequency of such late infective complications have been greatly exaggerated. In addition to the fact that our primary interventions each day have become more precise and more radical, the useful and indispensable control which the laboratory and neurological examination brings to us, awakens the hope that in the future these accidents will diminish still more. Tuffier in his report has noted in 6664 cases of cranial wounds observed 122 late accidents; that is to say, 94 cases of abscess of the brain (1.41 per cent.), and 32 cases of meningitis (0.40 per cent.). The late mortality attending this series was 1.24 per cent.

But aside from infection there exist other complications to be feared as attendants upon old wounds of the cranium and of the brain. Minor accidents are met with in the great majority of those who have been trephined. Further, such grave troubles as epilepsy, partial or general, are frequent. Tuffier found them 676 times out of his 6664 cases; that is to say, 10.14 per cent. Our personal inquiry still incomplete gives us almost an identical figure, 10.9 per cent.

What are the causes of these non-infectious post-traumatic accidents? A prolonged study will be required to make us positive, but already some facts have appeared on the way and useful therapeutic deductions may be made.

I. *On the Repair of the Losses of the Cranio-Encephalic Substance.*—If we take up for consideration behavior of the bony substance after trephining, we note the rarity of osseous regeneration. Practically when a loss of substance has been left to itself repair of osseous tissue never takes place.

The cranial bones are covered on their external face by a periosteum similar to that of other bones. Their internal surface is in intimate contact with the dura mater. Can this be considered as performing the office of an internal periosteum? As long ago as 1837, Dubreuil concluded from his experiments that the repair of loss of substance of the cranium was furnished by the periosteum and the dura mater. Ollier in 1859 demonstrated the osteogenetic properties of the dura mater. It is well known also that a bone of the cranium destroyed by a slow pathological necrotic process, as in

syphilis, may regenerate itself more or less completely, but in such a state there is the reactivation to osteogenetic property in consequence of chronic irritation. Nevertheless, notwithstanding the real osteogenetic power of these periosteal membranes, the bones remain after a large trephining in the state in which the surgeon left them. Sometimes, even, there may be observed after a long time enlargement of the breach in the cranium. Some authors have thought that they noted that, if the wound remains a long time open, the loss of bony substance tends to diminish. Perhaps we shall find in this fact a suggestion as to the cause of the absence of bony regeneration in the bones of the cranium. In fact, if the wound remains a long time open, the external periosteum and the dura mater coalesce very slowly. During the whole period in which the dura mater, the periosteum and the osseous cut surface remain uninfluenced by the process of cicatrization, the bone may possibly regenerate itself. It will be then by the occlusion of the surface of the fracture, by the fusion of the periosteum and the dura mater to which may be attributed the absence of regeneration. Growth of the borders of bony substance thus encapsulated by the periosteal-dural cicatrix can no longer occur. This union of the dura mater and of the periosteum presents also other inconveniences.

How is cicatrization of the substance of the brain and its envelopes accomplished? In a work which appeared in June, 1916, Bériel studies the cicatrization of open wounds of the brain. He observes the hyperplasia common to the tissues, dura mater, soft meninges, brain. In the meninges this hyperplasia induces a homogeneous increase of the tissue and constitutes a phenomenon of fortunate defense since it hinders the diffusion of infection. But as regards the cerebral tissue, it results in an increase in the connective tissue framework, a sclerosis of the neuroglia. Bériel believes that this junction, so useful as a barrier against infection, disappears after a time, and that progressively an isolation of the dura mater is produced. Liberation of the latter would be due to the movements of the brain which favor the redevelopment of the subarachnoid spaces.

The examination of microscopical preparations has not demonstrated to us such return of normal anatomical conditions. On the contrary, we have observed in the new formed epidermis a thick connective tissue layer, then in contact with this homogeneous layer a mixed layer where are mingled the elements of connective tissue with nervous elements derived from the neuroglia. The adhesions are very close and we have not been able to observe the cleavage noted by Bériel which seems to us more easily explained by a pathological process, a cystic formation, than by a return of the normal state. There remain then the following lesions:

1. In the brain a proliferation of the type of neuroglia.
2. At the level of the meninges a growing together resulting in fibrillous connective-tissue thickening, uniting on one side the brain to the hyperplastic meninges and on the other to the periosteum or to the connective tissue of the cutaneous cicatrix. There results from this a fixation of the

brain, a union at the circumference of the osseous breach and of the soft epicranial tissues. It is logical to admit that this process of sclerosis changes considerably the functional equilibrium of the brain. Its vascularization, the motility, the intimate function of the cerebral substance would be expected to be very profoundly modified.

II. *Non-Infectious Accidents Consecutive to Cranio-Encephalic Traumatism.*—From this category should be stricken out every accident which could have originated in an infection imperfectly overcome or recurring; symptoms also which are caused by destructive lesions of this or that center are not considered, such as hemiplegia, monoplegia, apraxia, astereognosis, hemianopsia, etc.; though, indeed, these sometimes are not the result of an anatomical destruction of corresponding centers, but come from functional interruption due to lesions of the neighborhood, compression, hemorrhage, etc. But such accidents are only temporary. Besides the disorders attributable to localized lesions of the encephalon, there are others much more frequent whose origins are less positively recognizable. Such accidents as headache, vertigo, psychical troubles, insomnia, emotional disturbances, varying much in their intensity, are observed in many cases. Pierre Marie has met them 98 times out of 323 old trephined cases.

Sometimes the subjective symptoms coincide with an objective element, such as changes in the cerebrospinal fluid, hypertension, sometimes lymphocytosis, but in such cases it is more likely that there is involved an old imperfectly extinguished inflammatory process or a meningeal infection in process of development. From what we know of the suddenness of the explosions of symptoms in cases of abscess of the brain in men who have for a long time already carried an intracerebral suppurating focus, we are led to the conclusion that important changes in the cerebrospinal fluid are connected with an infection.

Finally, the most frequent and most to be feared accident is epilepsy. Sometimes localized symptoms, generalized symptoms, severe even to the point of the production of extreme convulsive crises and even rapidly involving death, sometimes, on the other hand, slightly betraying itself only in slight symptoms, such as mental confusion and visual dazzlings.

Thus, the following situation is presented: On one side, accidents going even to grave epileptiform crises; on the other side an anatomical lesion consisting only in adhesions. It seems to us logical in the present state of our knowledge to adopt a treatment which should have for its object a suppression of this anatomical lesion and to hinder its production.

III. *Indications for Cranioplasty.*—To cure and above all to prevent important accidents which are so frequently the sequelæ of cranioccephalic traumatism, we possess in cranioplasty, preceded by encephalolysis, an efficient remedy.

The indications for cranioplasty are three kinds:

1. The restoration of external symmetry. Every loss of substance situated in the frontal or fronto-temporal region; every poorly healed cicatrix;

every loss of substance accompanied with marked depression comes under this category.

2. Prophylactic indications. To this class belong the following: (a) All cranio-encephalic lesions involving a loss of meningeal substance; (b) every cranio-encephalic wound which has healed by granulation; (c) every loss of substance of a dimension 3 cm. in diameter; (d) every loss of substance covered with thin and fragile connective tissue.

IV. *Curative Indications*.—Under this heading come: (a) Such accidents as headache, vertigo, etc., if they are troublesome by their intensity or by their frequency, when the infectious cause of these accidents can be certainly ascertained.

(b) Accessory accidents, grave or frequent, which are not caused by the existence of an intracerebral body or by a hæmatoma.

Contraindications.—Certain contraindications should be considered, such as:

1. The accident of the loss of substance; a relative contraindication which can be overcome by the adoption of some alloplastic proceeding.

2. The vicinity of the ventricles feared by some; but is not to be accepted as an absolute contraindication.

3. Permanent hypertension which does not give way to repeated lumbar puncture.

4. Every imbedded projectile which cannot be extracted, especially if it is not well borne.

5. Every syndrome which suggests the existence of a latent meningeal or encephalic infection.

6. The presence of splinters which cannot be extracted at the time of operation.

Most authors recommend that several months should elapse after the wound before intervention, but we do not share in this view. What these authors fear is that the intervention may reawaken an imperfectly extinguished infection. To-day, however, our patients when operated upon recover, as a rule, without infective complications. If, however, one has to do with a case which has undergone prolonged suppuration, or a case which has been complicated with abscess of the brain, one should wait many months and not intervene as long as there exist any symptoms of infection. As to this, systematically practiced lumbar puncture, as well as radiography, will furnish important information. The complete neurological examination and inspection of the fundus of the eye are equally indispensable before proceeding to operate.

With these reservations, early cranioplasty presents the great advantage of preventing accidents always to be feared after a cranio-encephalic wound.

The question of the date of the cranioplasty may therefore become an affair of convenience. Given a patient who has always been free from fever, in whom healing by first intention has taken place, who presents no symptom suggesting infection, one can practice the restorative operation as soon as

the state of the soft tissues permits of it, possibly a month after the wound.

Experience has demonstrated that the results in such cases are always favorable. In other cases one may wait; sometimes even operation must be refrained from altogether. We have done cranioplasty as early as twenty-four hours after the wound; the result was perfect, but as a matter of principle, we do not advise this manner of proceeding. It appears to us to be applicable without danger only in cases of simple cranio-encephalic wound in which the dura mater has not been opened, a case in which there is no important interest in supplying so early the loss of substance.

V. Operative Technic.—Operative technic should have as its chief aim to do a prophylactic or curative procedure, æsthetic and protective ideas being secondary. The objects are, therefore:

1. To remove the adhesions between the tissues of skin, cranium and meninges; and the meningo-encephalic substance.
2. To prevent the redevelopment of such adhesions.
3. To remedy the cranial defect which exposes the patient to danger in case of new traumatism.
4. The reestablishment, as far as possible, of the external shape of the cranium.

For the closure of the breach in the cranium one may possibly avail himself of: An osteoperiosteal flap from the cranium which may be turned down or slid over, so as to serve as a cover for the opening in the cranium. Free bone grafts are, however, more frequently to be employed, displacing inorganic materials which have formerly been relied upon. The method of free grafts dates from the experiments of Ollier in 1865. Such grafts are taken most frequently from the anterior face of the tibia. This source of plastic supply has been adopted by the author in his work. The reformation of the cranial skeleton is not the only thing which is to be considered. The removal of extensive adhesions and the repair of the dura mater are important operative indications. The graft reconstituting the meninges is as important as the cranioplasty properly so-called.

In 1893 Sacchi demonstrated that if in reimplanting the trephined button the periosteal surface was put toward the brain, one could prevent the formation of adhesions, even if there existed a loss of substance of the dura or of the cerebrum underneath. These facts have been confirmed by many authors and have influenced the present writer in the method which he himself has adopted. By a graft from the fascia lata one may cover over a large loss of substance of meninges.

Finally, a graft of fat tissue has been utilized to fill in a cavity resulting from a loss of brain substance.

Cartilaginous grafts have given in the hands of some very good results; but cartilage, well tolerated at the beginning, undergoes later absorption. The bone graft is the process of choice provided the grafts obtained retain their periosteum and are of slight thickness. Microscopical preparations

show that such a graft becomes the seat of two kinds of phenomena, resorption and regeneration.

In the performance of this procedure the most scrupulous attention must be given to the removal of meningeal adhesions and the prevention of their return. The trephine orifice should be fully exposed. In many cases enlargement will be necessary. Thus there is brought to view the area of adhesions or of the most pronounced sclerosis. It is necessary, then, with scissors and with bistoury to excise freely all tissue which is plainly cicatricial. This may sometimes carry one afar. One hardly knows how to fix a limit to this excision. Each individual operator must be guided by the gravity of the case as to how far his bistoury should go. After the excision has been made, one finds himself confronted by the loss of meningeal substance and sometimes of brain matter. For the repair of the meningeal substance, a fascia lata graft is the best method, the one whose results are most to be depended upon. Some points of suture with fine catgut fix the graft to the meninges. If the depression is very deep, hindering the osseous graft, it is well to have recourse to a fat graft. One may fearlessly place an adipose cushion in contact with the brain, but experience has shown that it is necessary to avoid grafting at one time too much fat. In fact, in such a case there may be induced a partial necrosis of the graft at its central portion, while the periphery attaches itself perfectly. Upon microscopical examination one sees these two zones, one where the cells are normal, and one where the clusters of adipose cells have disappeared, where one meets with fatty cysts.

The principal ends to which the surgeon should direct his efforts in putting the graft in place are to make the fixation sure; to put it in so that it may merge itself easily with surrounding tissues so that there may be hindered the formation of adhesions between it and the brain. It is not necessary to resort to points of catgut suture. The periosteum well raised up will permit the graft to be insinuated between it and the external table and will insure a sufficient fixation which will be further completed by the suture of the skin and epicranial tissues.

In placing in the graft, it is greatly to be preferred to turn its periosteal face toward the brain. Thereby will be reduced to the minimum the adhesions between the brain and the neighboring tissues, although the possibility of hyperostosis may render one careful. What appears most important is the fact that an osseous lamella insufficiently united to its periosteum, if it is thrown off, may readily be eliminated as a foreign body. If the osseous surface is turned toward the pericranium, a small incision may remove such a thorn. On the contrary, if it is under the graft, it cannot be removed and it is readily understood that it may determine accidents.

We have never had recourse to any drainage whatever; if the primary dressing is well done and no hæmatoma is formed, one has no need of it.

VI. *Wound Healing and Results.*—The wound healing is simple. Sometimes there develops slight œdema of the region—not enough to cause any

EDITORIAL COMMENT

anxiety. The graft at the end of the first week has become adherent to the neighboring tissues. It is practically solid. The immediate result is, then, perfect.

The amelioration of the subjective symptoms is constant, but one should be conservative as to his final results. The operation has an important influence upon the morale of the patients. There is always a disappearance of the fear which such men felt from the knowledge that they were insufficiently protected against external violence.

Up to the present time we have been quite reserved as to the final results to be expected, as far as it concerns the amelioration of the objectives trouble, and particularly epilepsy. Commonly after the intervention there is a temporary improvement, but this by no means indicates permanent amelioration or cure. As to such results the elapse of time must be awaited. But up to the present in the presence of accidents that are serious and which under treatment can be ameliorated, we have an operation simple and not dangerous for which logically one can hope success, so that the author does not hesitate to recommend routine recourse in such cases to free cranioplasty.

HARDE ON THE FREQUENCY OF TETANUS BACILLI AND OF OTHER ANAËROBIC MICROÖRGANISMS UPON THE SUR- FACE OF FRAGMENTS OF PROJECTILES WHICH HAVE BEEN EXTRACTED FROM WOUNDS *

At the beginning of the war tetanus was a complication quite frequent in wounds in consequence of the lack of antitetanic serum. Thanks to later systematic employment of preventive injections of this serum in all cases of wounds, the early tetanus, which appeared in the course of the first two weeks after the wound, has become very rare. There have remained, however, cases of delayed tetanus developing some weeks, or often some months, after the wound. The appearance of this late tetanus has often followed after a secondary surgical intervention. In the study of these cases of delayed tetanus, two factors have to be considered:

1. It is well established that the spores of the tetanus bacillus can remain a long time latent in a wound without provoking any symptom. Under the influence of a traumatism such spores may undergo development and tetanus break forth.

2. There is a second possibility—namely, that of contamination of the wounds in the hospital in the course of such intervention or of dressings.

When preventive injections of antitetanic serum have been made, a condition is produced wherein the wound may be soiled with tetanic bacilli and yet the man be protected by the injection of the antitetanic serum. The wound may give no indications of the presence of the bacillus of Nicolaier. Later, if adequate asepsis is not observed in all wounds, even those presenting the most reassuring aspect, there remains a risk of hospital contamination.

The literature shows that certain hospitals have a much larger percentage of late tetanus than others. Possibly these hospitals receive their patients from regions particularly subject to tetanus infection; but that may not be the only explanation.

In the course of former researches I have met with two cases in which the wounds contained the bacilli of Nicolaier, without any clinical manifestation of tetanus. One was a case of gas gangrene affecting a large wound of the thigh and of the knee; the patient died on the tenth day. In the other there was a penetrating gunshot wound of the thigh. The bacteriological examination had demonstrated the presence among other microörganisms of septic vibrio and the bacillus of tetanus. The wound became rapidly clean and no complications followed.

In consequence of these observations I have been stimulated to seek for the bacillus of Nicolaier in the wounds of patients who were not tetanic. In such a research one should remember that the bacilli of tetanus are often difficult to identify in a wound, even where tetanus is present. These germs

* Memoir by M. le Docteur E. S. Harde in the "Report of the Ambulance de l'Océan," at La Panne, Tome II, Fasciculus I, p. 185.

EDITORIAL COMMENT

are rarely abundant, they are difficult to cultivate, and in making an experiment one does not always obtain all of the flora of a wound.

A negative result, then, does not demonstrate absolutely the absence of an organism. Further, one must not lose sight of the fact that neither the identical form nor the cultural characteristics are sufficient to affirm at a given time the presence of the bacillus of Nicolaier. There is only one sure criterion—that is, the formation of a toxin which gives the classical symptoms of tetanus in animals in which the suspected bacillus has been injected. One does not admit the existence of non-virulent strains of pseudotetanic bacilli.

With these reservations I present my experiments at Paris in the service of M. le docteur Shutro, at the hospital Buffon. I have studied a consecutive series of thirty non-tetanic cases. The wounds studied date from some days to several months; all, after opening up, have been treated by the method of Carrel-Dakin. The microörganism of tetanus had not been found in any of these cases.

The method followed consisted in obtaining a specimen of wound exudate, a part of which was made use of to soil a splinter which was inserted into the muscles of the foot of a white mouse, an animal very sensitive to tetanus. This is a method of choice to prove the presence of a small number of the spores or of the bacilli of tetanus. A second portion of the exudate was employed for incubation in a medium very favorable for the multiplication of the bacillus of tetanus.

The exudate was implanted in tubes of gelatinized bouillon containing a fragment of muscle of beef or veal, the whole sterilized in an autoclave. These tubes of meat gelatine impregnated with the exudate were placed in the incubator at 37° C. The gelatine became liquefied, and the conditions favored a vigorous growth of anaërobic microörganisms, including the bacillus of tetanus. When microscopical examination of the cultures has seemed to indicate the presence of the bacillus of Nicolaier, these cultures have been inoculated by the intramuscular method into the white mice. By neither of these two methods was I able to demonstrate in the thirty cases examined at Paris the presence of the bacillus of tetanus.

With these negative results it seemed to me important to search for the tetanus bacillus on the surface of the fragments of projectiles extracted from wounds. The opportunity to make this study was given me by Professor Depage at the Ambulance de l'Océan at La Panne.

Sixty fragments extracted from wounds during the months of June and July, 1917, were subjected to examination, an examination which had for its object not only the search for the bacillus of tetanus but also the presence or absence of any anaërobic flora.

By cultivating the fragments together sometimes with pieces of clothing or parts of tissue remaining from the opening up of the wound, there was a greater chance of finding again the complete flora which soiled the wounds at the beginning than when one sowed for cultivation only the exudate; but neither one nor the other of these examinations could be considered as giving

an absolutely certain result. For example, in a case of late tetanus, not included in the present communication, with the late extraction of a shell fragment, neither the culture of the microorganisms of the fragment, nor the cultures obtained by impregnation in various media of exudate taken upon the day following, in different places of the wound, have given the germs of Nicolaier. Out of sixty examinations made, I have obtained a culture of tetanus bacillus only once. These fragments were extracted from half an hour to twenty hours after the wound, except in case No. 2.

The technic of procedure has been as follows: In the operating room the material to be examined has been placed in a sterile receptacle, then inoculated into the tubes of meat gelatine and then incubated at 37° C. for at least seven days.

I have taken care to examine the tubes several times during this period. In cases where the microscopical examination has shown the presence of microorganisms resembling morphologically the bacillus of tetanus, the cultures have been inoculated into white mice. Once only the culture has shown the bacillus of tetanus (Case No. 21). The patient presented five shell-fragment wounds and was operated upon five hours after having been wounded. There were present wounds of the soft parts only, without any fractures of bone. These wounds healed rapidly without complications. They were situated on the forehead, on the arm, on the thigh, on the ankle and at the great toe. The culture of the forehead did not give any anaerobics; all the others furnished them. The wound of the arm showed bacilli of the saccharolytic group, *perfringens* type. In the wounds of the thigh, of the great toe and of the ankle I was able to detect several kinds of anaerobic bacteria, and among them forms resembling the bacillus of tetanus. Nevertheless, only the culture from the fragment extracted from the ankle developed tetanus after injection in mice and guinea pigs. The other wounds gave only non-virulent cultures of pseudotetanus bacilli. All the wounds after having been opened up healed without complication. The wounds of the forehead, of the ankle and of the great toe were very slight, and in them, after the opening up, reunion was obtained in a few days.

The wounds of the thigh and of the arm, after having been opened up, were treated by the Carrel-Dakin method and sutured on the fifth day, with likewise reunion per primam. The patient had received the usual prophylactic injection of antitetanic serum, which was not repeated.

In seven cases out of the sixty there were found bacilli resembling morphologically the bacillus of tetanus, but being without virulence. These bacilli should be considered as pseudotetanic.

Fifty-two times (*i.e.*, 86.67 per cent.) there existed anaerobic bacteria which, according to the classification of Henry, were not only members of the saccharolytic group, including the *perfringens* bacillus, but very frequently also bacilli of the proteolytic group, including the bacillus *sporogenes*, etc.

There were also frequently associated with these streptococci and other

aërobic bacilli; but in no case of our series was there gas gangrene. I have rarely observed grave generalized infection, notwithstanding the frequency with which the surface of the fragment was strongly infected. This demonstrates once more the fact, already well established, that surgical intervention practised as early as possible in a wound and with a free opening up overcomes effectively the chief infection of gunshot wounds.

The results of these examinations relative to the presence of bacilli of Nicolaier should be compared with the statistics of cases of tetanus observed in the Ambulance de l'Océan at La Panne, and in the English army at the beginning of the war, when the employment of antitetanic serum had not yet become so common as it is to-day at the Ambulance de l'Océan. Doctor Govaerts has published the statistics of the first 800 patients brought to the hospital. In these, six cases of tetanus occurred; that is to say, 7.5 per mille. For the English army Bruce has published that in September, 1914, tetanus occurred in 16 per mille of the wounded. It would result from the present study that the bacillus of tetanus is met with in one out of sixty; that is to say, 16.6 per mille. All these figures are comparative. It is true that this figure increased in October, 1914, for the English wounded, to 32 per mille; but the English troops were at that time fighting in a region recognized as especially infected with tetanus, which was not the case in the wounded subjected to our own observations.

En résumé, the result of the examination of sixty foreign bodies, fifty-eight fragments of projectiles and two rifle balls, taken from wounds, was, first, that the bacillus of tetanus has been found once in sixty cases, or 1.66 per cent.; that anaërobic germs of many kinds, the bacillus perfringens and others often associated with streptococci, have been observed in fifty-two specimens, that is to say, in 86.69 per cent. of the cases, without any of these patients having later presented complications of gaseous gangrene or of grave infection due to anaërobic bacilli.

TREATMENT OF CHRONIC OSTEOMYELITIS OF TRAUMATIC ORIGIN*

AT the INTERALLIED CONFERENCE FOR THE STUDY OF WAR WOUNDS, held in Paris in November, 1917, the *Treatment of Chronic Osteomyelitis* was the subject of a communication by M. JACOB, of Belgium. The reporter prefaced his paper by calling attention to the gravity of the complication of chronic osteomyelitis in injuries of the bones from war projectiles. By repeated acute attacks it diminishes very greatly the working ability of all wounded men and exposes them to all the dangers of chronic infection. Through atrophic changes in the muscles, vessels and nerves that it produces in the part of the limb attacked, by the phenomena of chronic arthritis that it develops in neighboring articulations, it always entails a loss of function and sometimes accidents which demand amputation.

It is tenacious in its course, and its final cure is always difficult, sometimes impossible to secure. It is a frequent affection. Up to October 1, 1916, out of 12,201 wounded men brought to the base hospitals, there were 2682 patients who presented osteitic fistulæ which had been more than a year under treatment. At the same date fistulous osteitis alone represented from 80 to 90 per cent. of the entries into certain surgical services. At the time the Jacob report was made its frequency had much diminished, so that it was producing not more than 20 to 25 per cent. of hospital entries. The cause of this diminution was attributed to active and early surgical treatment directed against infection.

Chronic osteomyelitis may develop after a simple contusion of the bone, as after a fracture; it occurs also as one of the consequences of amputations; but the most frequent form, one much the more interesting from the point of view of treatment, is the osteomyelitis consecutive to open fractures, and this is the only form which the reporter proposes to consider in his paper.

Consecutive to an acute osteomyelitis a chronic form develops according as the area of fracture has been more or less judiciously and early treated. It is naturally favored by the presence of intraosseous foreign bodies and transosseous drainage. The view that an osteomyelitic cavity possesses the form of a transosseous tunnel possesses a certain importance from the standpoint of the operative treatment of osteitic fistula.

The bones most frequently attacked by osteomyelitis, as observed in the author's service at Val de Grâce, based upon his observations of 182 cases, are, approximately: the tibia, 22½ per cent.; femur, 20 per cent.; humerus, 17½ per cent.; clavicle, 10½ per cent.; bones of the forearm, 10½ per cent.; pelvis, 7½ per cent.; bones of the feet, 5½ per cent.; the spine, 4 per cent.; bones of the hand, 2 per cent.

The proper prophylactic treatment for the prevention of chronic

* *Comptes-Rendus de la Conference Interalliée pour l'étude des plaies de guerre*, 3d session, 5-8 Novembre, 1917.

EDITORIAL COMMENT

osteomyelitis is simply the early, adequate surgical treatment of fractures, viz.: a free exposure of the seat of fracture in the first hours which follow the injury; the removal of foreign bodies and of débris of clothing; excision of the track of the projectile through the soft parts, the removal of free bony fragments and the subperiosteal resection of bony fragments still adherent, but contaminated by septic foreign bodies; finally, immediate closure of the wound, or, if this is impossible, secondary closure after progressive sterilization under bacteriological control of the infected area. This treatment, applied extensively during the past months in the various sanitary units at the front, has given excellent results, and to it may be attributed the great diminution in the number of cases of osteitic fistulæ now under treatment in the base hospitals.

When, however, chronic osteomyelitis has developed, what is to be done? It cannot be too strongly emphasized that osteomyelitis is controllable only by an operative interference which involves the free exposure of the osteitic focus throughout its whole extent, in the complete removal of the lesions; finally, in the securing of the cicatrization after the bone cavity has been rendered shallow and fully open. The sooner this is done, the better; that is to say, the procedure should be resorted to as soon as the diagnosis is established.

From the point of view of diagnosis, the radiograph may furnish valuable information, much more important than that given by simple exploration with a probe, and every patient who is the subject of an osseous fistula should be subjected to X-ray examination. The X-rays may, moreover, reveal an unexpected projectile, or one which has not been extracted. In osteitis of the diaphysis they show the form and the limits of the bony callus and render visible the inflammatory cavity of the osteitis, its extent and the sequestra which are contained in it. All such sequestra are not necessarily in the area of the fracture. They are found often at a certain distance from this area along the track of fissures which earlier communicated with the fracture and which the reparative process has more or less covered up. One should not be content, therefore, with a single radiograph, but multiple radiographs should be made from different aspects of the bone, so as to reconstitute the type of the fracture and the track of fissures. Thus the operator may obtain important indications as to the diagnosis and the localization of sequestra, furnishing a valuable guide for their removal.

Again, in osteitis of the epiphysis the X-rays may make manifest the foyer of softening and the extent, sometimes considerable, of the decalcified zone about it.

Jacob is in the habit of having radiographs made after there has been placed in the fistula, or in each of the fistulæ when several exist, a piece of silver wire whose extremity has been blunted by ignition in an alcohol lamp. By this means the plate shows the fistulous track marked by the metallic thread and sometimes even the sequestrum down to which it

passes. Injections of the fistula with bismuth paste (Beck) may also be used to give a clear image of the fistulous cavity and its diverticula.

At the time of the operation the incision through the soft parts down to the bone should, as a general rule, be parallel to the long axis of the limb and should pass through the fistula; but should the fistula be seated in a position unfavorable or dangerous, one should disregard it and select the proper anatomical path for access to the region. Whatever its seat, the incision should always be long, for the induration of the soft parts renders their retraction difficult. Sometimes it may be even necessary to make a transverse accessory incision. When the bone has been exposed, the periosteum should be pushed back by the elevator throughout the whole extent necessary to give free access to the parts diseased. If there is present a transosseous tunnel consecutive to a perforation of the bone, or to the prolonged presence of a transosseous drain, this tunnel must be transformed into a trench by cutting away the most superficial portion of its walls. If an intraosseous cavity is present, it is necessary, by scissors or gouge, to penetrate to the bottom of the lesion by enlarging the fistula, or by creating a path of access to it through the excessive callus.

In osteomyelitis of the diaphysis this work is often difficult, for the osseous tissue is sometimes as hard as ivory. One is thus conducted into one or more irregular cavities, where one finds imbedded in fungosities and pus one or more sequestra. These sequestra are sometimes long, voluminous, and it is necessary to open throughout its whole extent the cavity which contains them in order to easily extract them. The sequestra-containing cavity should then be carefully curetted; the least diverticulum, the smallest recess, should be widely opened up.

In osteomyelitis of the epiphysis the lesions met with are quite different. The gouge, the scissors, the curet, penetrate spongy tissue, soft, friable, fungous in places. The sequestra are almost always small, like nuclei in the fungosities, and the cavities which contain them have indistinct walls. These conditions remind one of tuberculous caries. Here, again, it is necessary to take away everything which is diseased. All the softened tissue is curetted away until one arrives at a layer of resisting bone, which represents the zone of defense of osseous tissue.

In certain regions, particularly those of the great trochanter, and certain of the flat bones, such as the iliac bone and the scapula, the osteomyelitic process is often accompanied with proliferating spongy tissue, so that there is produced a real tumor, prolonging itself in an irregular manner between the neighboring muscles, a tumor which it is necessary to completely resect.

Whatever the form of the osteomyelitis which is being dealt with, the surgeon must not lay down his gouge, his scissors, his curet, until he has everywhere reached healthy tissue. He must not even hesitate, in cases, rare indeed, where the lesions have involved the whole thickness of the diaphysis, to break the continuity of the bony lever; that is to say,

EDITORIAL COMMENT

to make an osteotomy and to practise a subperiosteal resection of the segment of the diaphysis involved. Another indication for such an osteotomy may be found in a very marked deviation of the axis of the limb due to vicious consolidation of the fracture. It is sufficient at the close of the operation to put the limb in extension.

Any operation directed for the cure of chronic osteomyelitis is a procedure always long and difficult, sometimes serious in character. Good assistance is necessary, and excellent lighting. It is necessary, in fact, at every stroke of the gouge or of the curet, to see well what has been done; otherwise, one risks leaving unattacked a doubtful point, a small fungous recess, a small fistulous track which may become the beginning of a recurrence. It is always useful, often indispensable, to employ the artificial lighting furnished by a mirror.

All the diseased portions having been removed, the operation is not finished. There remains a cavity, a deep trench, which it is necessary to make as shallow as possible by cutting away its borders so that cicatrization can be induced. In this work of converting into a plane surface the deep groove, one must watch out not to diminish too much the strength of the bone, except in those cases where the extent of the lesion demands a true resection of the diaphysis. The operative wound should be left widely open without suture.

Post-operative Treatment.—Dressing should be done with great care, watching constantly that the wound of the soft parts is not closed before the cavity itself is filled in. At every dressing the walls of the cavity should be examined carefully to detect any doubtful points. A stroke of the curet made at the proper time may stop at once a recurring process of osteitis.

The author utilizes the interval irrigations with the Dakin fluid after the method of Carrel in the after-treatment. Ordinarily, about the thirtieth day he finds that the microbic count has then become so infinitesimal that secondary suture can be attempted with success. Attempts to hasten the cicatrization of deep cavities by filling them with a solidifiable mixture, or with a graft of adipose or muscular tissue, have not been followed by encouraging results. In a large number of cases in which such attempts have been made, the plastic mixture or the grafts have been thrown off. This is not to be wondered at, if one recalls that the microbic flora remain very abundant in the first days following intervention. So, also, any attempts made after several months' treatment have often failed. Such failures have, however, been less numerous when the plastic mixture has been used than with other methods. On the other hand, filling injection or grafting, or, even better, orthoplasty by a flap, practised after complete sterilization of the cavity has been secured, is strongly indicated.

Timid, limited operative attempts are almost always followed by recurrence, and they favor the extension of the osseous infection. The

number of patients upon whom it has been necessary to operate several times is considerable. In twenty-five cases of chronic osteomyelitis under the personal observation of the author, twelve had already been operated upon once in another hospital; four, twice; one, seven times, and one, eleven times.

Extensive and complete intervention done early gives to the patient the maximum of chance of definite cure. This is obtained after an interval of time which varies from a few weeks to six or seven months. He refers to fifty cases reported by Churto, who claims to have secured fifty complete cures. Jacob himself in forty-two cases personally operated upon had had thirty-eight of them discharged from the hospital cured; the remaining four were still under treatment and in good course of healing.

However, it is prudent to make some reservations. The osseous infection is extremely tenacious, and it is well known that it can be reawakened after years of cure apparently absolutely perfect. It is none the less true, however, that the early and thorough intervention is the only treatment that offers to the wounded the best guarantees against such recurrence. One may hope that as the result of such work one may no longer see reënter into the surgical service patients who have been operated upon several times and among whom the extension and the gravity of the lesions, and the general poor state resulting, finally make amputation imperative. He mentions especially one patient in whom he had been compelled to amputate the thigh as the result of a fistulous osteomyelitis of the femur consecutive to a gunshot fracture sustained forty-six years before, in 1870.

SIR GEORGE M. MAKINS, of London, said that the characteristics of traumatic osteomyelitis resulting from wounds inflicted by shell fragments vary according to whether the affection has been caused by the penetration of a foreign body carrying with it bits of earth and of clothing, and, second, upon the gravity and extent of the injury done to the soft parts in the neighborhood of the injured bone. It is in such initial phases of the affection in which reside the points of special peculiarity of a pathological character, while its later development differs but little from what has hitherto been observed in civil hospitals.

He referred to the brochure published by Martin and Petrie on "Phases of Infection Preceding Traumatic Osteomyelitis from Shell Fragments," their report having been based upon thirty-two cases of shell fractures of the bones of the limbs observed in a military hospital in France during the course of the year 1916-17.

The material for his own study was always obtained from an amputation operation, or from a resection of the large joints. It was kept on ice during the short period which intervened between the moment of the operation and that in which they were able to subject it to bouillon culture. The stages of infection, therefore, to which the study was given

EDITORIAL COMMENT

were those which preceded the full development of osteomyelitis. The progress of the microbic infection through the bone was studied by making transverse sections of the affected bone at regular intervals, taking away each time for bacteriological examination pea-sized fragments. Finally to avoid all error coming from the synchronous presence of another source of intrinsic septic infection, they removed during the operation blood from a vein, which also was afterward subjected to analysis.

In every infected comminuted fracture the first vehicle of propagation of the microbes through the bone is the blood-clot borne upon the bony fragments and by these brought between the walls of the fissures. Microbes may thus be carried to a portion of the bone, or to a joint distant from the primary seat of the infection, and all the parts of the bone may be infected unless the development of the bacteria is stopped by surgical intervention.

A second source of propagation is penetration; that is to say, by the direct development into the substance of the bone of germs which have penetrated into it at a right angle with the fractured surface.

All portions of a comminuted fracture are not infected simultaneously. At the moment when the wound is produced, germs are implanted only in the parts touched by the projectile, but from that point they propagate themselves into the tissues by a regular progress until they are stopped by a natural barrier or by surgical intervention.

The rapidity of propagation depends directly upon the two factors—the amount of infection brought in and the length of the fissure exposed to infection by the wound. The first of these factors depends upon the presence of the projectile in the wound together with its agents of infection, dirt, fragments of clothing, etc.; the last, upon the degree of muscular laceration in the neighborhood of the bone.

Fissures are important by reason of the readiness with which they transmit the infection to points distant from the principal fracture. These present an initial resistance to the passage of bacteria when the concentration of such bacteria is not too great, or their path of entrance not too ready; that is to say, when the extirpation of all the débris attending the wound and the taking away of lacerated tissue have limited the infection to the tissues about the chief fracture.

The Penetration of the Bone by the Germs.—It has been experimentally established that the degree of penetration depends first of all upon the abundance with which bacteria have been implanted upon the surface of the fracture. Bacteria have been found in a bone not submitted to surgical cure at a depth of 10 cm. Again, the power of penetration varies according to the type of the germ, so that the variety of the infecting agent should be taken into account in each particular case. Nevertheless, since mixed infections are frequent, and it is not always possible to make a rapid bacteriological analysis of the micro-organisms introduced

EDITORIAL COMMENT

into the wound, there remain other points more urgent to be discussed.

The degree of bacterial infection upon the fractured surface at a given moment depends directly upon the following factors:

(1) The time elapsed since the wound.

(2) The blood supply.

(3) The surgical cares which have been given to the bone or to the soft parts.

(1) *The Influence of Time Elapsed Since the Wound.*—Although it is hardly possible, whatever the variety of the case may be, to give an exact formula as to the rapidity of penetration, observations made in sixteen cases of different fractures, in which the other factors played an insignificant part, enable us to come to the following conclusions, namely:

In cases where a septic wound has been submitted to adequate surgical treatment and to systematic cleansing the infection of the bone attacked may limit itself entirely to the superficial surface. The force of penetration reaches its maximum during the first days after the production of the wound and decreases to such a point at the end of the first week that a reaction of immunity is established. Although the data are too few to permit the enunciation of a rule based upon statistics, we are nevertheless warranted in making the general statement that the penetration of germs takes place in the majority of cases at the rate of 1 cm. to every sixty hours.

(2) *Blood Supply.*—The influence of a slackening in the circulation of the blood upon the development of germs (anaërobia particularly) through the tissues is known and has been demonstrated with precision in the case of infection of the muscles. The same general principles apply equally to bones, but the anatomical structure of the latter determine certain deviations upon secondary points. Many experiences have shown that one cannot attach too much importance to the question of the blood supply, and that every interruption in such supply, whether as the result of the initial trauma or as the result of surgical intervention, is a usual precursor of chronic osteomyelitis.

(3) *Surgical Treatment of the Bone.*—The reporter confines his observations in this communication to operations directed to spongy tissue rather than to the compact wall of the bone and the marrow. The fractures which have been subjected to study with the greatest care have been those in which the shell fragments have penetrated into the articular extremity of the bone of the limb. Around the fragment is found a layer of necrotic tissue formed by blood-clots and crushed bony trabeculae. This layer is in immediate contact with fragments of infected clothing; beyond extends a zone of spongy tissue devitalized but not crushed, the depth of which varies according to the force of the blow. As long as the layer of necrotic débris upon the surface of the fracture has not been taken away the drainage of the wound is powerless to resist the progress of septic penetration. If, on the contrary, after the lacerated tissue has

been cut away, the fracture is cleansed until there remains no débris, the entire remaining bone may be made capable of resisting infection until a protective barrier of granulating tissue is established; or by adequate drainage of the bone wound the bacterial penetration as a source of suppurative osteomyelitis may be almost entirely removed.

(4) *Surgical Cares Given to the Wounds of the Soft Parts.*—Imperfect drainage of a wound increases the facility with which the bacteriological penetration in the fractured surface takes place. The number of germs brought into contact with the open osseous surface is continually increased and bacterial penetration may reach a minimum depth of 2.8 cm.

The most common of the varieties of bacteria and the degree in which the variety of the germ may influence bacterial penetration is shown in the following table:

<i>Variety of bacteria</i>	<i>Average penetration</i>
Streptococci	10 cases, 2 cm.
Staphylococci	6 cases, 1.5 cm.
Anaërobia	6 cases, 0.8 cm.
Bacilli coli	3 cases, 0.7 cm.

CONCLUSIONS.—*Pathology.*—The infection of a fractured bone may propagate itself slowly from the original seat of infection. The advance of the germs is effected both by extension along the surface of the fractures and by direct penetration into the bone and the soft parts. The rapidity of the propagation of the disease reaches its culminating point during the first days and may be increased by insufficient blood supply and by defective drainage of the bone and soft parts.

Treatment.—The rapidity of the progress of bacterial infection in a fractured bone permits the formulation of the following axioms, the application of which is important in securing consolidation of fractures from certain projectiles. These axioms are:

(a) Operation with the briefest delay possible. It should be a question of hours, not of days. The surgical intervention should be based upon the examination of the particular pathology of the case. Primary healing has the least chances of success when the muscle is much lacerated and particularly when the injury of the muscle is parallel to the fissure and when the circulation is seriously interfered with.

(b) The excision of the wound should include not only the taking away of the necrotic tissue, clots of blood and foreign bodies (including therein fragments of bone separated from their periosteal connection), but also that portion of the bone lying in contact with the projectile. The depth to which the soiled part should be taken away varies according to the time which has elapsed since the wound had been sustained. Although it may not be stated exactly, one can nevertheless calculate such depth to have reached about 5 cm. at the end of twelve hours, when the sub-

sequent phases of an osteomyelitis which has reached its full development may be summed up as follows:

Almost every case is accompanied by necrosis, varying from a slight superficial exfoliation of the bone to total necrosis of the whole thickness of the bone for a variable length beginning from the initial wound. The bone which survives in the zone of inflammation presents symptoms of rarefying osteomyelitis which manifest themselves more especially in the cancellated bony tissue. Rarefying osteomyelitis is sometimes followed by secondary sclerosis of extreme density, and particularly in the presence of a localized injury not severe enough to cause fracture, often containing a foreign body. The propagation of the infection is not always continuous. Healthy portions of bone may alternate with infected portions, or with small localized abscess cavities; in which latter cases the infection is probably due to infected thromboses.

Another characteristic of osteomyelitis resulting from infection of the fracture produced by shell fragments is the tendency to produce an excessive callus extending over a large surface. This tendency is due to the scattering of osseous elements throughout the surrounding tissue by the initial injury and by the fact that the infection stimulates the formation of callus. An example is the osseous masses which after amputation often block up the medullary cavity and envelop the end of the bone.

From the surgical point of view, a notable fact is the slightness of the symptoms observed in the part attacked during the first phases of the disease. This is explained by the tendency of the disease to limit itself at first to the portion of the medullary canal which is widely open. The serious subperiosteal modifications manifest themselves later and a diffuse and progressive suppuration under the periosteum is rarely produced, so that the symptoms of osteomyelitis are often those of a general toxæmia or more rarely of septicæmia. Cases of characteristic pyæmia accompanied by secondary abscesses in other parts of the body have been rare, although the mode of propagation of the disease by progressive invasions originating from localized points may be considered as being of a nature identical with that of pyæmia.

The essential treatment of the osteomyelitis arising in cases of osseous fractures of bones should be prophylactic. The infection propagates itself comparatively slowly, and it is sufficient to cleanse at once the infected surface to a depth of 5 cm. to prevent the disease. All surgeons who have studied the question are agreed that the solution of the problem depends above all upon the resistance to infection of the tissues about the bone attacked, and that it is necessary in consequence to make certain the total absence of germs in such tissue rather than to direct surgical attack to the bone itself.

The prophylactic treatment of fractures may then be summarized as follows:

EDITORIAL COMMENT

- (a) Complete mechanical cleansing of the injury of the soft parts.
- (b) Careful removal of free or displaced fragments.
- (c) In the case of shell wounds, particularly those involving the cancellated tissue of the bone, the taking away of the surface which has been brought into momentary or prolonged contact with the projectile.

Ideal primary union of the wounds is rarely obtainable, and in the conditions prevalent in actual war should not be attempted except in certain exceptional cases.

Closure of the wound on the twenty-first day after the fracture is generally possible. It protects the patient against the dangers of a possible return of infection.

The bone of an amputated limb is often already the subject of an osteomyelitis at the time of the operation. If, however, the operation is an immediate one, there is a chance that the bone will still be healthy. In case of immediate operation it is recommended that the sawing through of the bone be conducted under the current of an antiseptic solution, and in doubtful cases the section should be followed by the application of a powerful antiseptic. The chief blood-vessel of the limb should not be ligated above the level of the stump, except for some special reason, in order that as great a degree of vitality as possible may be maintained in the tissues about the bone involved.

The treatment of osteomyelitis developed in the bone remaining after amputation may be necessary in cases of immediate and progressive infection. In such cases the granulation tissue upon the surface of the wound and the rarefied bony tissues, as well as every foreign body, should be taken away by means of a curet; then free drainage is established from the exposed medullary cavity. Throughout the treatment every effort should be directed toward maintaining the soft parts in the best state possible. If such measures do not result in staying the disease, a second amputation is indicated, even the entire ablation of the bone.

In some cases the taking away of a sequestrum may lead to a cure. In older cases, again, it is sometimes necessary to remove the sequelæ of osteomyelitis before being able to adapt an artificial limb to the stump.

In cases where osteomyelitis and suppuration persist in the fractured bone the first indication of treatment is to make sure of free drainage of the medullary cavity and of the space included between the chief fragments. Such drainage can sometimes be established only after the removal of a sequestrum, in others only after the ablation of fragments which by their shape or their position form an obstacle to drainage or sterilization of the cavity. If the patient suffers from toxæmia, or severe and prolonged septicæmia, amputation is necessary, and complete extirpation of the infected bone may be recommended.

In cases of prolonged suppuration having its source in a strongly infected medullary cavity, openings for drainage should be made along

the whole length of the bone, or the infected medullary cavity may be laid open throughout its whole extent. When the development of granulations upon the surface of a bone exposed and deprived of periosteum is slow, it may be hastened by boring a certain number of holes into the bone.

If at the side of the fractures important thickenings of osseous tissue develop, without solution of continuity, linear osteotomy or a removal of a portion of osseous tissue may hasten the cure and remove the pain.

In certain cases large masses of callus, accumulated through the infection or inflammation in certain regions, as, for example, in the abductor muscle, may be taken away in order to prevent deformity or to restore the function of the muscle invaded, or to restore to the limbs freedom of movement.

M. CONRAD said that the treatment of traumatic osteomyelitis has as its well-defined object the sterilization of the wound, so that a secondary closure might later be secured under bacteriological control. The osseous infection has benefited very greatly from the adequate adoption of this treatment. Three indications have to be met: (1) The fight against infection by one of the methods generally adopted to-day (of Carrel, Wright, etc.); (2) the removal of all foreign bodies, fragments of clothing, projectiles, etc.; (3) the removal of splinters.

When the bacteriological control permits the delayed primary suture, or, as is most frequently the case, the secondary suture, the osteomyelitis will have shared in the benefits of the general treatment and will be cured; but when the treatment has been poorly conducted, either through faulty technic or because of the wound having been sutured too early, latent infection of the wound is reawakened under the influence of a new traumatism, or often by some cause not recognizable. All the symptoms of osteomyelitis may then reappear with greater clearness. An abscess is formed, the surgeon opens it, and very regularly the wound heals with the persistence of a fistula. At other times the gunshot wound, although not subjected to secondary suture, closes by granulation without a persistent fistula.

Commonly, when one speaks of a traumatic osteomyelitis resulting from gunshot wounds we think of the patient at the stage in its evolution in which the formation of a fistula has taken place. This is an error which should be earnestly protested against.

How is it necessary to treat the bearer of a fistula?

At first, it is necessary to care for the skin-eczema which too often contaminates the circumference of the fistula. This is easily accomplished by aseptic dressings. Then by adequate interference may be taken away the anatomical cause which produces the fistula. The fistula may be kept up indefinitely by a foreign body; by sequestra free at the bottom of the fistula, or confined by osseous callus; eburnated callus poorly

nourished, or by callus with cavities filled with fungosities, with pus and with small sequestra; false joints with intervening sequestra, or whose extremities are necrosed or the subjects of osteitis and on the way toward necrosis; the stumps of amputations, too often the subjects of osteitis.

In every one of these, to obtain a definite cure, it is necessary that the offending condition should be removed or resected. In each case examination indicates the technic to be followed.

The speaker, however, submitted some general ideas as to treatment. In particular he emphasized as important that the track of the fistula should be subjected to stereoscopic examination to determine its anatomical relations and the presence of sequestra or of foreign bodies, furnishing valuable information to the surgeon in choosing his path of attack, in establishing his operative technic, in recognizing the anatomical causes of the fistula, and their nature, and their number.

When everything has been removed the cure is definitive without danger of recurrence. The path of access should always be very free. When attack is made upon a flat bone, all the diseased parts should be resected.

Especial mention should be made of the vault of the cranium, where too often are found sequestra involving the internal table, notwithstanding the sound condition of the external table. The short bones should be resected, although in some, as in the calcaneum, may be practised some cartilaginous *évidement*.

So also, in dealing with the diaphyses of the long bones, care is to be taken to avoid penetrating into the joint. In a diaphysis of the long bones the cavity should be freely uncovered. Diseased bones should be cut away down to healthy tissue. After the foyer has been cleansed, the margins of the osseous wound should be clean, smooth, regular, taking away enough to permit the skin to cover them and to be held in contact with its surface throughout the whole wound.

He did not favor the use of pastes (Mosetig, Beck). They do not take away the cause of the evil. At most they can bring an apparent cure, but recurrence is inevitable.

The fistula is ordinarily accompanied by atrophy, by musculo-tendinous stiffenings which often are extensive enough to render the limb completely useless even after the final cure of the fistula. Mechano-therapeutic treatment has a place in the care of these lesions, but it will not produce its full effects in cases still curable until the anatomical cause is taken away; until the fistula is definitely suppressed and the cure of the musculo-tendinous stiffenings is no longer hindered.

The author advocates early intervention, because the cure can be obtained only by taking away the cause which lies at the bottom of the fistula; because it is of greater importance in the contest against the musculo-tendinous lesions in the neighborhood to institute as rapidly as possible mechano-therapeutic treatment, the good effects of which cannot be definite unless the osseous lesion is cured.

A single exception is possible; certain sequestra, such as those which form in the extremity of ununited fragments of long bones, require some time to separate themselves. In such exceptional cases the surgeon looking out for them will readily judge as to the moment for intervention.

In general, the author advocates prompt operation as soon as the fistula with its special characteristics is clearly established. He resects, without longer waiting, the extremities of fracture fragments, the necrosis of which is to be expected even before the sequestrum has limited itself, relying upon the good effects of the Carrel treatment to strangle the osteitis in its course of evolution.

Conclusions.—The conference, after the presentation of these papers, adopted the following minute:

"As to the treatment of chronic osteomyelitis:

"(1) Osseous infection is produced by the same mechanism as infection in other gunshot wounds. It is propagated in two ways, either by steady progress through medullary and compact tissue, or to a distance along the fissures. The penetration through the osseous tissue is generally slow and limited.

"(2) Among the bacteria which first penetrate are streptococcic, staphylococcic, enterococcic, and more rarely anaërobic germs. In the microbic flora of the subacute or chronic suppurations of the bone they find most frequently the same bacteria.

"(3) The treatment of chronic osteomyelitis is first of all preventive; that is to say, simply the treatment of the foyer of the fracture.

"(4) The treatment of established osteomyelitis is purely surgical. It should be instituted early. It consists essentially in:

"(a) A wide opening of the infected focus;

"(b) Careful search for and ablation of all sequestra and foreign bodies;

"(c) Converting cavities into plane surfaces.

"(5) These operative steps accomplished, two methods remain;

"(a) Either the immediate closure of the wound, secured, if necessary, by flap autoplasty;

"(b) Chemical sterilization of the wound and secondary autoplasty as required to fill in the osseous cavity and to permit of its suture.

"The latter method is most generally applicable."

FINAL RESULTS OF THE TREATMENT OF FRACTURE OF THE SHAFT OF THE FEMUR *

DR. TH. TUFFIER, of Paris, contributed to the Interallied Surgical Conference, held in November, 1917, the result of his studies on the results which had been attained in the treatment of fractures of the femoral diaphysis among the French troops.

The material upon which he had based his report included 16,392 cases. All the information received with regard to these cases was not of the same value; a large number could not be used because in the earlier months of the war the records were not kept with as much care as later. Moreover, all these injuries dated from the period extending from August, 1914, to December, 1916, a period particularly unfavorable in the treatment of fractures. For this reason the results obtained were unfavorable. Another cause of error is that in order to establish the exact gravity of such accidents it is necessary to know the precise number of fractures of the femur since the beginning of hostilities, in order to know in what proportion the results obtained have been unsatisfactory. Such information is not available; though it is impossible to obtain them at the present moment, he had every reason to believe that especially the unfavorable cases were generally included in the histories obtained, since he had had to do with invalided or pensioned patients.

The seat of fracture has in this plan a very marked importance. It is the fractures in the lower fourth, or in the upper fourth, of the bone which give the worst results.

Methods of efficient treatment applicable to fractures in general are often unavailing in fractures of the femur. Out of three hundred thousand invalids pensioned on account of gunshot wounds, there were 119,663 fractures, of which number 16,392 were fractures of the thigh. These thigh fractures were under treatment from four months to thirty-seven months, an average of fifteen and one-half months. The best statistics are furnished by the Hospital for Fractures at Châlons, which reports an average of treatment of ninety days. The functional state in all was reduced to a point which made their degree of invalidity exceed 10 per cent., for below that point the wounded were not invalided. As to the various degrees of invalidity, 22.42 per cent. were reduced to an absolute functional loss of power of the limb. A lameness of variable degree, spontaneous pains, pain provoked by walking, even to the extent of the permanent use of crutches—such are the troubles constantly noted in these cases.

As to the causes of these disabilities, in the first rank is bone infection, chronic osteomyelitis. It is almost constant in the history of these injuries. The difficulties and the length of its treatment, the necessity of several suc-

* *Comptes-Rendus de la Conférence Chirurgicale Interalliée pour l'étude des plaies de guerre*, 3d session, 5-8 November, 1917, p. 233.

cessive operations to bring it to an end, play a capital rôle in the later disabilities due to these fractures. Second, the shortening of the limb is constant and varies from 1 to 20 cm. Out of 883 cases, 43 were shortened at least 3 cm.; 191, 6 cm.; 225, 9 cm.; 390, more than 9 cm.

When this shortening is alone and exceeds 5 cm., it determines marked trouble; but it is frequently associated with rotation and angulation. It is generally due to overriding of the two fragments, much more rarely to the loss of substance completely separating the two extremities of the bone. In all the cases where it is due to overriding of the fragments it is a surgical question. This is a point upon which too much insistence cannot be placed. Outward rotation of the lower fragments aggravates notably the trouble in walking. It is present in 70 per cent. of the cases. Lastly, the angulation is of the classical form; that is to say, with its convexity forward and outward. In numbers of cases the deformity is not only curved; it is more than a curve, it is an angle. The loss of function due to these shortenings can be avoided in most cases, excepting only the shortenings due to real loss of bone. The rotation, and especially the angulation, is always due to imperfect surgical treatment. After consolidation has been accomplished, it does not follow that the patients are guaranteed from accidents of osteomyelitic attacks in the callus.

These may present themselves under two aspects clinically, in general of slow development. At the beginning a sense of pain in the limb; a sensation of heat at the level of the callus or of one of the cicatrices, then a painful localized swelling with redness and œdema. These symptoms last for some days, then improve and disappear, only to manifest themselves again some weeks or some months later and to end by the formation of a fistulous track. Or a simple traumatism or overuse may provoke the signs of acute osteomyelitis with suppuration. A fracture of the thigh once infected is never free from the possibility of such accidents, at any period of its existence. He had seen operated twenty-five years after their fracture men who had been wounded in the war of 1870. What establishes their gravity in any general estimate of late results of treatment of fractures of the thigh is the frequent powerlessness of means of treatment.

Free resection, wide, deep, of the whole focus until the healthy bone is exposed; the prolonged disinfection of the surfaces and of the old cavities; their closure with bacteriologic control, and their being filled with living tissue may give success that curetting and restricted resections will fail to establish. The general therapeutics is, in fact, that of osteomyelitis.

In addition to such osteomyelitic attacks, irregular and deforming callus is the rule in fractures of the femur which have undergone suppuration.

Of 161 cases of deforming callus examined by the X-ray, he found 94

cases of excessive deposit of irregular shape invading muscles and becoming, by their interference with muscular action, a cause of disability; that is to say, 58.4 per cent.; 37 cases of angulation callus; 21 cases of considerable overriding; in 9 cases the fragments presented such a degree of overriding that amputation had to be practised; but the callus itself may be in fault, although such cases are relatively rare. Pseudarthrosis, which is not to be confounded with prolonged delay in consolidation, is especially grave. It is fortunately less frequent than in the bones of the forearm and arm, which occurred upon an average in 14 per thousand cases. Further inquiry at the orthopædic service at Paris as to this proportion elicited the fact that in that service 10 pseudarthroses of the thigh had been observed and 30 cases of soft callus, while the fractures of the arm had given 500 pseudarthroses, and fractures of the leg 400. It is very difficult to establish the causes of such pseudarthrosis and to know whether the extent of the removal of the splinters may not be the chief cause but it seems in all cases that the suppuration of the two osseous extremities may be the most frequent determining cause. If suppuration has been prolonged, the treatment of such accidents is always grave and is accompanied with loss of functional power in the limb and varies with the length of osseous substance lost. When it is not extensive, the freshening of the bony ends, their suture by metallic plate or a graft, with or without osteoperiosteal clothing, constitutes the method of treatment of choice.

Subjects of surgical treatment also are the ankyloses of articular stiffnesses affecting the knee and the foot or the hip. These accidents are extremely common, amounting to 76.2 per cent. of all cases, and have played a very important part in the determination of the functional trouble presented by the patient. Stiffness of the knee occurred in 38.8 per cent.; complete ankylosis in 22 per cent.; stiffness of the knee associated with complete or incomplete ankylosis of another joint was met with in 35.6 per cent. The other articulations are less frequently affected; the hip in 5.55 per cent., the foot only in 4.12 per cent.; but it is the associated ankyloses of the hip, of the knee and of the foot which are the most frequent—the knee, the hip and the foot in 1 per cent.; the knee and the hip in 6 per cent.; the knee and the foot in 12 per cent.

These frequent ankyloses, single or compound, in joints which have not been affected by the traumatism show imperfection in the surgical treatment. An early and properly conducted mobilization would save the patients from such grave complications.

The author remarks that many times among the late distant results of fractures of the thigh they met with coincident mechanical troubles, the ensemble of which alone was the source of grave loss of power. A relatively slight shortening with considerable rotation becomes quite serious; if to it is added a stiffness of the knee, as happens in 46.6 per cent. of the cases, the loss of function of the limb becomes considerable and the degree of infirmity is notably increased. To prevent such accidents,

therefore, should be a matter of constant attention by surgeons treating such injuries.

The operative treatment of these deformities and these joint lesions includes the straightening of the limb and the mobilization of the joints.

The straightening of the limb in cases of angulation or axial rotation of the fragments is accomplished by osteotomy. Two conditions may be present, determined by the existence or non-existence of an osteomyelitis.

In the first place, the resection of the callus to its full extent and the denudation of healthy bone, and the methodical disinfection after the method of Carrel, have given the best results. If, however, there are no infectious phenomena, a wait of several months should be allowed before practising simple osteotomy and the reduction of the deformity, whether by traction through an apparatus, by immobilization, or by suture of the bone. In case of shortening with angulation, osteotomy and reduction may even produce an elongation of 6 cm. in extent.

But outside of operative treatment, examination of fractures of the thigh shows very often that functional troubles are due to muscular atrophy involving one or a group of muscles. The author has seen in a number of cases, by simple education of the defective muscles, a restoration of the power such that, notwithstanding the persistent bony deformity, the functional trouble disappeared in great part.

Besides such muscular trouble, one finds at a distance, in fractures of the thigh, vasomotor troubles, which appear and persist during the first months. Often they produce delay in cure; but when such œdemas are considerable and become chronic and hard, when the vasomotor troubles characterized by redness of the limb below are considerable, they become a complication relatively grave.

Finally, trophic troubles may be due to concomitant injuries of the large nervous trunks; they are relatively rare, having been found in only 91 cases. Of these 36 were lesions of the sciatic, 42 of the external popliteal, 5 of the internal popliteal, 3 of the external and internal popliteal, 4 of the crural nerves. These injuries are particularly grave, for secondary suture of these large trunks is unreliable.

The primary cause of defective results in the treatment of fractures of the thigh sustained during the first three years of the war is recognized as infection of the wound and of the osseous focus, for the non-infected fractures give results equal to those in times of peace. The infection produces secondary osteomyelitis, the duration of which is uncertain and which necessitates a prolonged treatment. The long duration of the treatment, the difficulty of making the dressings and of maintaining at the same time exact coaptation, explain the frequency of the alterations in the axis of the limb, the angular deformities, the deposits of deforming callus, the musculo-periosteal adhesions and the vicious cicatrices, all of which result in loss of function. The shortening of the limb is the factor of least importance in the scale of these deformities.

EDITORIAL COMMENT

These results can be, and will be, very notably bettered. The primary or secondary closure of these fractures will prevent all the accidents due directly or indirectly to the osteomyelitis; that is; rapid disinfection will make it possible to escape all those infectious complications which lead to prolonged suppuration, even amputation; by shortening the duration of the treatment which will protect from accident on the side of the knee, the hip and the foot, and, finally, they will permit the surgeon to direct his whole attention to the orthopædic question, and the overridings and the deviations in axis will become by so much diminished. The joints of the knee and of the foot will no longer be left stiffened, and false joints will diminish in frequency.

The report submitted gives a résumé of a bad period in therapeutic history, and the reporter did not doubt that a review of the results obtained during a later period would show results infinitely more favorable.

LATE EXTRACTION OF MISSILES IMBEDDED IN THE LUNG

(*Extractions de projectiles intra-pulmonaires chez d'anciens blessés.*)

DR. R. OLIVIER* says that in January, 1916, he was placed in charge of a surgical service in which were included thirty cases of wounds of the chest in which the projectiles were still retained in the lung. Of these only fifteen were subjected to operation. In some of those that were not operated upon the small size of the foreign body and the absence of all symptoms contraindicated intervention. Others refused to permit themselves to be operated upon, affirming that they were doing well enough and they saw no necessity of undergoing the surgical attack. Of the fifteen who accepted operation, some did so because they were suffering from various symptoms which caused them anxiety, the others because they could not bear the idea of retaining a foreign metallic substance imbedded in their chest.

Of all these men, the most recent wound dated back five months. The symptoms which they presented were for the most part vague, such as variable interference in respiration and some painful phenomena. All were able to assist in hospital duties and all had been actively employed in the care of the hospital garden. All had borne without pulmonary disturbance the winter's storms. Several since their wound had made another campaign and had supported its fatigues without trouble. It is proper to say that these latter were energetic men. Only two of the patients among those under observation presented a serious condition dependent upon the presence of the projectile, indicating clearly the necessity of intervention.

These two wounds dated back to the battle of the Marne. Since receiving their wounds they had not ceased to suffer. In one, simple hemorrhages were provoked by any slightly prolonged effort; in the other, besides repeated hemorrhages, sometimes severe, there was constant expectoration of foul pus, particularly abundant in the mornings. In both these cases the general state was seriously affected. The first of these was subjected to operation, with the result that the hæmoptysis had ceased. The other, notwithstanding his grave condition, declined operative relief. The symptoms in these cases, in most of them, were, however, very slight and seemed more frequently to be due not to the projectile, but to the remains of ancient pleural effusions. As to whether such retained projectiles might later provoke accidents is uncertain.

In the course of the operative work the author had always been surprised at the very slight extent of the pulmonary lesions which were found. There had been met every degree of pleural adhesions, from almost total adhesion down to some very slight and loose adhesions; but when the projectile was exposed in the pulmonary parenchyma, very

* *Lyon Chirurgical*, May-June, 1918.

frequently the foreign body was surrounded by a very thin sac well limited, and immediately outside this the pulmonary tissue became healthy, supple, elastic. The condition was quite otherwise when the projectile by its presence was determining the trouble. Then there was more or less of intense local reaction, with the sac much less clearly limited; sometimes an abscess around the foreign body, which lesions were accompanied with clinical manifestations. The author asks again whether, when such clinical manifestations are absent, the projectile has become definitely inoffensive?

It is certain that in case of the development of subsequent pulmonary disease a retained projectile may easily become an additional cause of an abscess of the lung or of pulmonary gangrene. Even without apparent cause an abscess may be produced around such a projectile, as has taken place occasionally in other parts of the body.

The author discusses the question of anæsthesia in cases in which projectiles are to be extracted from the lung. As a rule, he had employed general anæsthesia. He never saw any serious accident excepting in one case, in which he was obliged to suspend the operation. The ether and chloroform were almost always well supported, and there were no post-operative accidents due to anæsthesia. He had, however, been surprised with the good results which attempts at local anæsthesia had given him. He made use of a 1 per cent. solution of cocain or 1 per cent. adrenalized novocain. With this solution the tissues in the whole operative zone were freely infiltrated. When the rib was exposed, the needle was directed toward the root and parallel to the edges, and several cc. were injected around the intercostal nerves. With this simple local anæsthesia he had always been able to make whatever intervention with the lung was necessary and to extract the projectiles by whatever method was required.

In one case, in which in the absence of a primary fixation of the lung a total pneumothorax occurred, the lung was drawn out through the wound, the missile removed and the lung was sutured, followed by suture of the wall, the patient himself did not perceive the occurrence of the pneumothorax. The only result was that the respiration became a little superficial; the pulse was not disturbed and the operative course was facile. In other cases, also, he has extracted projectiles through an opening deliberately made in the pleura, and always the pneumothorax was well supported. It was very evident that but little gravity attached to the operative pneumothorax. It is well to know that even with simple local anæsthesia thoracotomy with pneumothorax may be resorted to if it is indicated.

The whole history of surgery of the lung has been dominated by fear of the dangers of the pneumothorax much more than that of the operative lesion of the lung. The latter is generally well supported when it is done with prudence. That in the surgery of the lung little gravity attaches to the pneumothorax as an operative step has further been

demonstrated by experience in wide thoracotomy for search for projectiles according to the method of Duval. The only precaution to be observed is to produce such a pneumothorax slowly. Frequently the suture of the lung is not sufficient to prevent more or less bloody effusion into the pleura taking place from the lung; more or less serious infection may result according to the virulence of the infecting bacilli, varying from a simple pleural reaction with serous effusion, which is the most frequent condition, to the most grave putrid, purulent pleuritis.

It has seemed to the author that the operative consequences were the more serious when the pneumothorax had been created through a high thoracotomy, the gravity increasing in measure as the summit of the pleural cavity is approached. This is probably due to septic liquids tending to collect at the lowest point and infecting thus a much larger extent of surface. He has noted also that the pleural reaction accompanied with more marked cardiac phenomena had been notable in those cases in which the internal face of the lung was involved in the extraction of the projectile.

In those cases in which operative intervention had been employed where the lung was adherent to the pleura, the better progress of such cases was due, in his opinion, not so much to the absence of the pneumothorax as to the more direct drainage of the lung sac in which the projectile had been imbedded by a drain, which brought directly to the outside any septic products, with the formation of a zone of adhesions separating the large serous cavity from the pulmonary operative focus.

When forceps extraction is possible, the tract created is of small diameter, closes immediately because of its obliquity, and produces no pneumothorax, no effusion into the pleura.

The morbidity attending the extraction of foreign bodies of the lung may be more or less great, according to the method employed; but when a sufficiently long period has elapsed since the date of the wound, the mortality will be very slight. Marion in 150 cases had but one death. Though the risk may be slight, do the final results obtained warrant its practice? One can reply in the affirmative without hesitation in those cases in which the presence of the projectiles is producing accidents, such as hemorrhages, purulent expectoration and other phenomena of pulmonary reaction. All such symptoms disappear after the extraction of the foreign body. This fact appears to be clearly established, but it is far from being clear that relief can be expected from such symptoms as pain and respiratory difficulty in prolonged efforts and in severe labor. The cases operated upon by the author, five months later when examined, were found to present a functional condition identical with, or even less satisfactory than, that which had preceded operation, excepting in those cases in which there had been present hæmoptysis and purulent expectoration, which phenomena had disappeared quickly and had not returned. Radioscope showed the existence of a pleurodiaphragmatic pathology, which

did not exist before. Examination made in these cases later showed the same functional trouble. The author believes, however, that they will diminish in time.

Technic.—Four methods are mentioned: (1) the method with fixation of the lung (the method of Marion); (2) the transpleural method with pneumothorax (method of Duval); (3) the method of extraction with forceps guided by fluoroscope (method of Petit de la Villéon); (4) a mixed method, secondary fixation of the lung after extraction.

The method of Duval is rapid, elegant, everything that can be wished for when its object can be realized; that is to say, extraction of the projectile and fragments of clothing, and cleansing of the pleura. When the ribs are separated by powerful instruments it is easy to explore the lung. The projectile is generally felt, the lung is brought to the outside, the foreign body is taken away and hæmostatic suture can be done. It is a perfect method when the foreign body is seated upon the external face of the lung. It is quite otherwise when the region involved is the posterior mediastinal region. The extraction, and, above all, the suture, are then very difficult. In the author's opinion, this method is the best for danger-making missiles where it is necessary to choose between possible immediate accident and later septic accidents, which are very greatly reduced in their seriousness as the result of the operation.

The author has subjected three patients to operation by this method, and in all cases the later consequences were simple. The first case was accomplished with a purulent pleurisy in consequence of an accident that he should have avoided. There were two projectiles, one of which fell into the pleural sac and produced a purulent effusion, which later was overcome by Dakin irrigations. The second also was a pleurisy, at first serous, then purulent. The projectile was seated at the bottom of an interlobar fissure and the hæmostatic suture was almost impracticable. In the third case everything passed smoothly and the suture of the lung was carefully done. Some serous effusion followed, but without serious consequences.

The method of Marion, in the presence of existing adhesive fixation of the lung, was followed in eight cases. The simplicity of the operative steps and all its later consequences was astonishing. There were no complications in these cases and the eight patients were up by the twelfth day. In all cases the projectile was found except in one case, in which there was an error in the localization. Some of these projectiles were situated very deep. The liberation and extraction of the foreign body was effected with great care, never attempting to take away the projectile by a forceps upon the finger, but always the operation was done with full sight, not hesitating to make a very large opening; indeed, this opening was much more a crowding back than a wound. There was no hemorrhage.

For very deep projectiles the operation may be conducted in two

steps. In the first step one goes as far as the projectile. If the extraction appears dangerous, a tampon should be inserted. Some days later the case can be resumed, and the extraction, according to Marion, is then greatly facilitated. However deep the track through the lung tissue, its walls fall immediately together and the track does not seem to produce any complication.

The principal objections attach to the fact that a zone of solid adhesions is created around the site of the interference, and also that only the foreign body is seen and the condition of the pleura is not ascertainable.

In the cases reported by the author the post-operative course was always excellent and identical. The temperature charts seemed copies one of the other, an elevated curve for three days up to the taking away of the drain. As soon as that was taken away the temperature fell and remained normal. The small drain orifice cicatrized, and by the twelfth day the patients were all up. Some spat pus for two or three days, but all quickly returned to a normal state.

The method with secondary fixation of the lung, as employed by the author, was the result of two incidents. The first happened in the course of an attempted extraction by the method of Marion in which fixation was not present. The incision opened at once the pleural cavity instead of the lung. In the second case, in the course of an extraction by the transpleural method, with pneumothorax, the operator found himself confronted by an abscess surrounding the projectile. After incising the lung and extracting the projectile, with opening of the abscess, he made a careful encircling suture, which united the lung and the costal pleura, and inserted a drain. The later progress of the case was perfectly simple.

The extraction of the projectile under the guidance of the fluoroscope, the method of Petit de la Villéon, was used in some cases. At first sight this method seemed the better, both from the point of view of the facility in extraction and also the simplicity of the aftercourse. It is not so. It is a blind, unsurgical method. The object should be not only to take away the projectile, but also, and above all, fragments of clothing which may have been carried in with it. More than the metal itself, these débris cause complications. If the forceps extraction does not remove them, the work is only half done.

The other methods employed constitute, on the contrary, true surgical methods, permitting the accomplishment of everything which is necessary to full extraction of foreign bodies and the drainage of the lung when that is necessary.

DEPAGE ON THE OPENING UP OF GUNSHOT WOUNDS*

DR. A. DEPAGE, Director of the *Ambulance de l'Océan*, devotes the first pages of his second annual report to a discussion of the treatment of gunshot wounds in general. He says:

When a gunshot wound of the soft parts by a rifle ball is found to present a punctate opening, it is rarely necessary to open it up. Such a wound track heals, as a rule, spontaneously without provoking any complication. Exception should be made to wounds produced by bullets received close to the muzzle or at a short distance; such wounds demand opening up. The projectile determines almost always in such cases the shattering of the tissues, a real explosive effect, having an area of disturbance more or less deep, prone to necrosis. In such cases it would be unwise to refrain from intervention. Again, a wound should be opened up when a ball has divided an important artery and an aneurysmal hæmatoma has been created. Interference in such cases should never be undertaken except by an experienced surgeon. Ligation of the two ends of the vessel should be made, or arteriorrhaphy if coaptation is possible. When a large artery is divided and the life of the limb is in danger, the operator should avail himself of the paraffined tube of Tuffier.

Division of the large nerve trunks also calls for immediate opening up of the wound. It is impossible to insist too strongly upon the importance of examining a patient upon his reception at the hospital as to motor and sensation function in the territory of the nerve supposed to have been wounded. The course to be pursued is the exposure of the nerve, the suture of its refreshed ends and the imbedding of the sutured trunk in the neighboring muscular tissue.

Fractures by rifle balls as a rule do not demand to be opened up. The operative indication depends much more upon complications, such as have just been mentioned, than upon the fracture itself.

Wounds by Artillery Projectiles.—Here the conditions are not the same. The wounds sustained by fragments of shells or of shrapnel are much more grave and are always infected. Should, however, the small fragments not exceed in size the volume of a millet seed or of an oat grain, they may be abandoned in the soft parts, especially if they are multiple in number. Every projectile of large dimensions should be extracted. The treatment of the wound will vary according to whether the lesions involved are superficial or deep.

Subcutaneous tracks, comparatively little soiled, may not imperatively demand opening up. However, it is much better to do so, because of the frequent presence in the track of particles of clothing carrying infection. If circumstances permit it, the thing to do is to extirpate the track *en masse* through sound tissue and make immediate suture. If the wound presents only a point of entry into a subcutaneous track, the extraction of the projectile

* Ambulance de l'Océan, La Panne. Travaux publiés sous la Direction du Dr. A. Depage.

is to be effected. However, if the depth of the subcutaneous track does not exceed from 2 to 3 centimetres, it is not necessary to open up, for the foreign body with the clothing débris may be extracted by means of a simple curette. If the track is longer, there is no further discussion as to the necessity of opening up in all cases.

By free opening of the injured area decompression of the tissues bound down by aponeurotic sheaths is effected and the escape of secretions favored. The surgeon seeks to protect the patient from septic complications and to put the wound in the most favorable conditions for cicatrization and for suture. To realize this double end, it is necessary to remove from the wound not only the foreign bodies soiled by microorganisms (projectiles; débris of clothing, etc.) but also the devitalized tissue, such as flesh, contused, necrotic—a condition favorable for microbic growth. It should be noted that the zone of injury, of cell depression, is not limited to the tissues which come in direct contact with the projectile, but extends from a half to a whole centimetre beyond, even to the depth of 2 centimetres. The vitality of these tissues is involved and there is every advantage in removing them from contact with the elements less involved, or even unaltered. It is often the early period at which the first intervention is done and the minuteness with which it has been practised that determines the later progress of the wound and the possibility of rapid repair.

The Operative Technic.—Some surgeons have recommended to take away the traumatized area *en bloc*, as one would take away a tumor. The length, the depth and the direction of the track being exactly marked out by the use of a metal sound and the wound being perfectly isolated from the operative field, they carry around the orifice an oval incision whose main axis corresponds to the direction of the wound track. They divide successively the skin, the connective tissue, the aponeurosis and the muscles, keeping constantly in healthy tissue so as to carve out a mass which includes the track in its totality. Thus, they take away *en masse* all the injured tissue, taking care, meanwhile, to keep the healthy track protected from contamination. Immediate suture is then done. Such a complete operation would constitute without doubt an ideal mode of intervention, if the traumatic areas were always regularly delimited and if one could cut into the flesh without any anxiety as to the organs which were enclosed. But such conditions, it is hardly necessary to say, are never realized when one has to do with lesions extensive and deep, so that the method described can be reserved only for short and superficial tracks.

The only truly rational procedure consists in the wide opening up of the foyer, as is practised by the great majority of surgeons.

Before proceeding to the opening up, the surgeon should picture to himself as exactly as possible the configuration of the track through the different anatomical planes. In the case of through-and-through wounds the apertures of entrance and of exit are to be noted. In the case of wounds with one orifice of entry only the topographical situation of the projectile should be

determined by the X-ray or by the electro-vibratory apparatus. After the general plan of the track has been laid out, the incision should be planned so as to permit complete access to the wound without producing new anatomical injuries. The direction of the incision should vary according to the region wounded and the nature of the wound.

In the arm, forearm and lower third of the leg transverse incisions should be refrained from, because they endanger the section of important organs. Longitudinal incisions alone are admissible; whether one has to do with a lesion presenting a single lodging point, or whether an anterior and a posterior point require simultaneous attention. These incisions should always be sufficient to permit a complete opening up of the track.

A wound involving the front of the leg calls equally for a longitudinal incision, with the exception, that in the upper third a wound of the anterior tibial artery may demand a transverse section of the muscle.

In the thigh, anteriorly and posteriorly, in the popliteal space, and in the calf of the leg, through-and-through wounds and simple penetrating wounds should in general be approached by incisions parallel to the axis of the limb. Transverse incision in these cases does not offer any advantage and is likely to occasion extremely serious injuries. Two longitudinal incisions, the one anteriorly and the other posteriorly, will always permit the thorough opening up of the foyer.

In cases where the muscular masses are too thick to permit access to the deep parts of the track by longitudinal incision only, cases in which very free opening up is necessary throughout the whole depth of the wound in order to provide against the accidents of gaseous infection, it will often be necessary to resort to transverse incision, dividing the muscles or part of the muscles interposed between the surface of the skin and the deep track. In wounds of the anterior face of the thigh, one will have to incise the anterior rectus, the vastus externus and sometimes the tensor fascia lata; on the posterior face, the biceps and the semimembranosus; in the calf, the gastrocnemius, and in the posterior face of the arm, the triceps. Such transverse sections should involve only the muscles and the aponeuroses, avoiding the nerves and the blood-vessels.

At the end of the procedure it is important, when possible, to reestablish the continuity of the divided muscles by suturing with catgut and by partial suture of the aponeurosis and the skin.

Transverse section thus done should leave behind no loss of function, provided, of course, that the suture holds. If doubt exists as to the full cleanliness of the deep wound, the suture of the divided muscles may be postponed for two or three days, when the surgeon can have assurance as to the nature and degree of the final infection. In some circumstances when the opening up has been resorted to very late, or there already exists a deep infection, immediate suture of the muscle ends must be refrained from.

Excision of the Tissues.—If a superficial track is to be dealt with, the free edges of the orifices should be resected, and these should be united by

dividing the bridge of intervening tissue so as to transform the track into a groove. Then, with the aid of strong scissors the injured tissues which carpet the sides and the path of the groove are completely cut away.

In case of a blind wound, or a deep through-and-through track, the first step, likewise, should be the resection of the free edges of the orifices of entry and exit to the depth of from 1 to 2 centimetres, circumscribing each of these orifices by an elliptical incision.

Each incision is enlarged until the foyer is opened up from one or both directions, according to whether there is or is not an orifice of exit. The superficial aponeurosis is incised to the same extent as the skin. Pursuing the track further into the depths of the tissues, a director should be introduced into the wound, using one which will separate easily the muscular fasciculi. The best means of reaching the foyer is to raise up with two forceps the edges of the muscle in following the track and resecting the contused parts layer by layer. If at any moment the track is lost, which often happens in the deep parts, the gloved finger introduced into the wound finds it again without difficulty. It is important to note that the divided muscles retract, and when this has taken place the ends should be sought out in order to excise the contused parts.

The injured muscle tissue should be resected throughout the whole face of the wound down to healthy tissue. This is recognized by its contractility and its red tint, which contrasts with the dull color of the contused muscle.

When the projectile has been reached by this process of approach, it is removed together with fragments of clothing. After the foyer has been widely exposed, it is best to irrigate the wound with Dakin fluid or preferably with warm physiological serum which improves the appearance of the contused and injured parts.

In case of fracture, the question of the removal of splinters of bone has often been discussed. Surgeons have not reached accord as to this point. Some find that it is better to take away all splinters by a subperiosteal method; others abstain from any splinter removal, or take away only the splinters lying free in the foyer. The problem is, indeed, difficult to resolve and it will be only with time and experience that our ideas will become fixed. Our own practice is as follows: If the wound is such that an immediate suture can be attempted, we take away the splinters that are free, taking care always to leave the osseous bridge between the fragments. If, on the other hand, it is plain that the suture cannot be done by reason of the extent of the injury, we no longer take away any splinter in the course of the operation, thinking that it is better to allow to be spontaneously thrown off, as the process of granulation progresses, the splinters which become necrotic. This last method of procedure offers the great advantage of lessening the dangers of a pseudoarthrosis and of notably shortening the primary operation, an item which should be taken into account when dealing with a severe fracture in a patient who is in a state of shock.

Suture of Wounds.—When a gunshot wound is opened up, in order to

prevent the development of infection, one should seek at the same time to put the wound into conditions most favorable for suture.

This may be done immediately after the incision—immediate suture—or after five or six days—delayed primary suture—in which case it is done as the immediate suture, without refreshing, by simply bringing into apposition the wound surfaces. Lastly, suture can be done after chemical sterilization of the wound, secondary suture. This is done after the eighth day, when the wound has become covered with granulations which necessitate always the refreshing of the wound surfaces, and it is this which distinguishes it from the preceding sutures.

As to the indications for these various methods of suture, the following are formulated:

(A) *Immediate Suture*.—Indications vary according to the region wounded. For wounds of the joints immediate suture is imperative, excepting in the presence of very extensive osseous lesions.

In wounds of the cranium, of the face, of the feet, of the hands, the rich vascular supply, both bloody and lymphatic, permits the surgeon to make immediate suture in a systematic way.

As to wounds of the soft parts and in case of fractures, the indications for immediate suture are very relative, although surgeons are coming more and more commonly to practise it. It may be done any time within twelve hours after the wound, but only when the surgeon can continue to watch over his patient for at least fifteen days. It offers as an advantage the complete anatomical repair of the wounded tissues, but the infections which may disturb are often rapid and severe, such as diffuse phlegmonous infections and gaseous gangrene.

(B) *Delayed Primary Suture*.—This is adapted particularly for wounds of the soft parts and open fractures. It may be made if bacteriological control shows its propriety. As practised by us it is as follows:

At the first dressing, 12 to 24 hours after the opening up of the wound, a smear is taken for immediate examination and the secretion is submitted also to culture.

At the second dressing, 36 to 48 hours after the opening up, a new smear is taken. If the culture of the first smear does not reveal streptococci, and if the microbial count does not exceed one microbe in two fields, suture is practised.

We never suture if the count at the second dressing shows an increasing microbial growth, even if the microbes are not pathogenic. Delayed primary suture rarely fails on account of grave later complications. It only offers the slight inconvenience of two operations.

(C) *Secondary Suture*.—This is reserved for wounds which cannot be sutured during the first days because of too extensive destruction of tissue, or because of a threatening infection. It presents the great advantage of giving complete safety, but delays the healing and never gives as complete an anatomical restoration as do the primary sutures.

EDITORIAL COMMENT

We practise it regularly when the microbial growth is maintained at a point of less than one microbe in four fields at two successive examinations, and when the culture is free from streptococci. Although experimentally we had sometimes resorted to suture in the presence of streptococcus, the deplorable results obtained in such cases have caused us to finally establish rules quite precise as to the indications and contra-indications of secondary suture.

The following table gives the statistics of sutures done in the Hospital de l'Océan, from May, 1916, to November, 1917. The failures are due in most part to the presence of streptococci in the wound.

	Total	Complete Success	Partial Success	Unsuccessful
		<i>Per Cent.</i>	<i>Per Cent.</i>	<i>Per Cent.</i>
1. Immediate suture:				
Cranium, face, hands, feet.....	491	473-96.3	8- 1.6	10- 2.1
Large joints: without osseous lesion.....	66	62-95.9	.....	4- 6.1
With osseous lesion.....	79	71-89.8	1- 1.2	7- 9
Soft parts.....	380	319-83.9	24- 6.3	39- 9.8
Fractures: Femur.....	4	4-100	.....	.....
Other bones.....	26	20-76.9	3-11.34	3-11.54
2. Delayed primary suture:				
Cranium, face, hands, feet.....	18	18-100	.....	.....
Soft parts.....	222	207-93.2	8- 3.6	7- 3.2
Fractures: Femur.....				
Other bones.....	20	16-80	4-20	.....
3. Secondary suture:				
Cranium, face, hands, feet.....	64	58-90.6	4- 6.2	2- 3.2
Soft parts.....	845	724-85.6	70- 8	51- 6.4
Fractures: Femur.....	39	30-76.9	7-17.9	2- 5.2
Other bones.....	102	92-90	3- 3	7- 7

TREATMENT OF WOUNDS OF THE FOOT*

DR. A. DE PAGE and DR. L. DELREZ present as the second paper in tome 2, fascicle 1, of the scientific reports of the Ambulance de l'Océan (La Panne, Belgium), the results of their work with wounds of the feet.

I. *Skin Wounds*.—Losses of substance from the skin of the foot are very difficult to repair. They result from a traumatism which has torn off and destroyed a flap of skin, or are consecutive to the retraction of the borders of a wound which it has been impossible to suture immediately. The retractibility of the skin of the foot and of the regions below and behind the malleoli is very marked, the divided edges separate from each other, turn back and very quickly become attached to the bone. Simple linear wounds of however small extent and however slight the detachment of their edges, often leave granulating surfaces which prevent complete apposition.

In most cases we have to leave these granulating surfaces to healing by a second intention, to a spontaneous epidermization which always gives an adherent cicatrix with all its inconveniences. Plastic operations do not offer any help here; there is no sliding possible. At most, when the situation permits it, one can utilize the skin of a toe to cover a granulating wound. More serious still are losses of substance from the sole of the foot and from the heel. The skin in these regions presents special characteristics which are indispensable to enable it to support the weight of the body. The cicatrix resulting by second intention at this level interferes much with walking. On account of these considerations, the following conclusions are formulated:

The greatest parsimony should be exercised in making excisions of contused skin, either on the dorsum or on the sole of the foot. The scissors or the scalpel should take away the least amount of skin possible and this minimum should be confined to the immediate edges of the wound. The well-nourished skin of the foot can reestablish itself more easily than can the fleshy parts of the member.

To escape the immediate and later inconveniences of healing by second intention, it is important to practise to the fullest degree possible immediate sutures of wounds of the feet, whether they involve the soft parts or skeleton.

In cases where the immediate suture appears dangerous, it is necessary without waiting for the wound to become sterile, to proceed at an early time to at least a secondary suture, even though it may be partial, in order to prevent retraction of the edges and further adhesions to the underlying tissues.

The application of these principles may lead to immediate suture in most cases. Happily, the blood and lymph supply of the foot is very rich and inflammatory accidents are the exception.

Lacerated and contused wounds of small size may easily be sutured, but large wounds are more difficult.

* Ambulance de l'Océan, La Panne. Tome 2. fascicle 1. p. 9.

Sometimes the traumatism has produced a true scalping of the foot, the skin is torn and often rolled up as far as the middle of the sole. In such a case we cut away a strip of the skin and of the subcutaneous connective tissue. We examine the wound carefully and we practice the suture of the flap without drainage. To favor the reestablishment of the circulation, it has appeared to us useful to practice numerous scarifications of the free edge if cyanosed. These scarifications permit the venous blood to flow out and empty the capillary system of the flap and facilitate the reestablishment of the circulation in parts menaced by gangrene.

The fear of severe infection in important injuries of the foot, or the necessity of rapidly terminating an operation on account of the general state of the patient, sometimes obliges the surgeon to give up attempts at immediate suture. In such cases as soon as circumstances permit it he should make always a total or partial secondary suture without waiting for surgical sterility of the wound. Incomplete secondary sutures of wounds of the foot, non-sterile, as a rule are not followed by accidents.

Autoplastic Grafts.—Losses of substance resulting in the tearing off or destruction of a portion of the skin of the foot give rise to most serious difficulties. On the sole they are physiologically beyond repair; one is compelled to abandon such a wound to secondary cicatrization which always gives a defective result, or one has to deliberately sacrifice a part of the bony framework.

Losses of substance seated on the dorsum of the foot may be repaired, either by making use of the skin of a toe disarticulated for that purpose, or by having recourse to autoplasty.

We call *greffe en cascade* an autoplasty which we have practised with success and which consists in taking a flap at a distance from the wound. At the first step this flap is twisted upon its pedicle and fixed by its border nearest the wound. At the second step the pedicle is divided and the flap is submitted to a second twisting which brings its bloody surface over the wound.

In wounds of the sole of the foot involving the soft parts only, it is necessary to avoid as far as possible large incisions, with the view of preserving to the skin all its properties. The incision should be preferably transverse in the posterior region, and in the middle of the foot they should be longitudinal in the anterior region.

Wounds of Tendons.—Those of the tendon Achilles are the most important. Their gravity is realized above all when the tendon is completely cut through and is followed by retraction of the triceps of the calf. They are in general complications of a lesion of the heel and of the posterior portion of the os calcis.

These wounds, above all when they are the result of an artillery projectile, should always be opened up and the surgeon should explore and refresh the tendinous insertions sufficiently to reestablish the continuity of the tendon. If the insertions are completely detached, the thing to do is to reestablish them as far as possible. If the tuberosity of the os calcis is

entirely destroyed, one can fix the tendon to the periosteum if it has been sufficiently preserved, or to the plantar aponeurosis. Immediate suture is of advantage in all cases. If it has not been possible to do it for any reason whatever, secondary suture should be applied as early as possible.

Finally, when the fixation of the tendon Achilles cannot be realized, one should never lose sight of the fact that by its elongation the functional mobility of the foot may be restored. The lesions of the extensors and the anterior tibial do not present any complications. Suture is generally done to restore their continuity. Those of the peroneals are more difficult to treat, not in consequence of retraction, which is never an obstacle to the suture, but because of the destruction of the tendinous sheath which is impossible to restore to its natural state by suture. Most of the time the sutured tendons have to be left in a tendinous gutter and remain there in contact with raw tissue. It is interesting to note that such little favorable conditions in general do not leave permanent trouble as far as the ulterior function of these tendons is concerned, contrary to what is observed in the hand.

Infections of the tendinous sheaths of the lateral peroneals at the neck of the foot as a rule lead to progressive phlegmons which on one side ascend to the external aspect of the leg and on the other gain the sole of the foot. Such phlegmons are complicated, besides, generally with inflammatory lesions of the tarsal bones.

Lesions of the Bony Framework and of the Joints.—These wounds often result in important mutilations.

The most simple case is a fracture of one or two metatarsal bones, the projectile remaining imbedded in the tissues. The operative interference consists in excising the injured edges of the orifice of entrance and the bruised soft parts and in making a very careful removal of the bony splinters, even to the extent of subperiosteal resection with a toilet of the bony ends. The projectile is removed in the course of the operation and the whole procedure is terminated by immediate suture. When the orifice of entrance is seated on the dorsum of the foot, as is most frequent, we avoid any incision on the plantar surface unless the foreign body projects under the skin. An extensive loss of substance in the neighborhood of the head of the metatarsal may require the removal of the corresponding toe. When the first or the fifth metatarsal bone is involved, a transverse incision is practised to expose freely the fracture and to facilitate the removal of fragments. A through and through wound of the metatarsus should be treated in the same way. Too often the surgeon is tempted to be conservative. It is an exception to see a fracture of the metatarsus heal spontaneously without accidents of infection.

In wounds by projectiles of large size, the injuries are more important and involve generally several metatarsal bones. These bony injuries require resection or disarticulation of the injured metatarsal bones with removal of the corresponding toes. Lesions of the borders of the foot are *a priori*, more severe because they compromise the foot as a means of support.

The surgeon should be sparing in making resections of the metatarsal bones; in fact, the fifth metatarsal represents, as we have seen, an essential part of the anterior arch of the foot, and the first metatarsal with the great toe constitutes also an important point of support. We have always observed very satisfactory results from amputation following the internal and external borders of the foot. In both cases, the upright position and the walk remain easy, though running and leaping are seriously hindered, less, however, than after the disarticulation of Lisfranc.

Transverse penetrating wounds with fracture of several of the metatarsal bones should be treated on the same general principle as isolated fractures. The wound should be opened up by resection of the two orifices, followed by a transverse incision connecting them, which permits the injured bones to be reached easily.

Finally, in very extensive destructions of the metatarsus and of the toes, the only resource is the disarticulation of Lisfranc, which furnishes a very good stump. Walking, even for a long time, is easy and without fatigue. Running only is prevented.

Wounds of the Tarsus.—Wounds of the anterior or posterior tarsus may be divided into two classes: first, wounds from artillery projectiles of small size which involve only bony and articular disturbances of slight importance; second, the great injuries of the bones and joints produced by voluminous fragments by which one or many bones are shattered and corresponding articulations opened up.

The treatment of wounds by small projectiles does not differ from that which is required by wounds in general and those of the metatarsus in particular. Free opening up is essential with excision of all the contused parts. Osseous tunnels should be cleaned out with the greatest care. As far as possible, the operation should be terminated by immediate suture without drainage, or with filiform drainage. Most frequently such wounds heal without complication.

Wounds by voluminous projectiles may in some cases be well handled by a free opening up and by removal of bony fragments with an attempt at primary suture, especially when one has to do with lesions involving the anterior portion of the tarsus; injuries of the cuneiform bone, the scaphoid and cuboid; one may sometimes arrive at the same result in isolated lesions of the astragalus and of the calcaneum.

Removal of the astragalus, followed by immediate suture, is an operation much to be recommended. But when destruction of the posterior tarsus exceeds certain limits, it is better to make outright a supramalleolar amputation.

Large infected wounds of the tarsus always constitute grave lesions.

EDITORIAL COMMENT

The complexity of the joint surfaces which ramify between the different bones renders drainage difficult, often inefficient. Suppuration persists in the foyer; it often invades the tendinous sheaths and leads to the formation of pus pockets about the malleoli and in the leg. The general state is greatly attacked and more than once we have seen the blood become involved in the infection.

The final result of these shatterings of the tarsus treated by conservative method is often very little encouraging. The bony destruction produced by the traumatism aggravated by the suppuration often leaves upon the tarsus a large cicatricial area which lends itself badly to support and offers no flexibility to the walk. So we have come to the practice in these cases, at least for the anterior tarsus, of making an atypical transverse resection. This operation is not regulated by any fixed point as a guide, it is only determined by the particular characters of the bone and joint lesion. Two transverse saw cuts are made and the entire bony mass between the cuts is taken away, preserving the plantar surface of the foot. The front of the foot is united to the tarsus by an immediate metallic suture, or if infection is to be feared, by a secondary suture made after the wound has become sterile. The preservation of the front of the foot is very useful, it helps in maintaining the standing function of the foot by preventing the astragalus from becoming rotated as occurs after the operation of Chopart. Besides, as the tibio tarsal and subastragaloid articulations are preserved, the foot maintains its mobility. Owing to these two factors the walk preserves its flexibility, which is not so in cases of the Chopart and Pirogoff operations. The results of amputations and disarticulations of the tarsus by the method of Chopart, Pirogoff, Malgaigne and Syme are alike as regards function. We have rarely had occasion to practice them in the course of the war. The Pirogoff has given us good stumps. As to our disarticulation, after the method of Chopart, we know the final result only in one case. The operation completed by transverse division of the tendo-Achillis has left a quite useful stump, although slightly retracted. The division of the tendo-Achillis is not sufficient to hinder a stump from sliding downward and forward. We believe that it becomes turned for two reasons: first, because the posterior arch of the foot being no longer supported falls, and more especially because the astragalus under the pressure of the tibia becomes rotated forward.

Simple wounds of the *tibio tarsal articulation* are to be subjected to the same treatment as articular wounds in general, free opening up, excision of the contused tissues, extraction of the projectile, toilet of the synovial membrane, immediate suture. Functional restitution is complete and rapid, especially when the operation has been followed by early mobilization. The

greater the bony lesion, the more uncertain is the result. It must be left to the experience of the surgeon to determine those lesions in which it is impossible to practise conservation and suture. We have been able, among other cases, to obtain very good results in cases where one of the malleoli or one of the borders of the tibial mortice has been shattered. In cases where intra-articular shattering of the astragalus has occurred, the removal of the astragalus appears to us to be always indicated, but in order that this operation should leave any mobility to the foot, it is necessary that an immediate suture should be practised. In cases in which suppuration has taken place every precaution must be taken necessary to prevent the development of an equinus. For the large lesions of the posterior tarsus, that is to say, where both the astragalus and the calcaneum together have been shattered, preservation should not be attempted in most cases. It exposes the patient to serious peril, while the functional results are absolutely bad.

In cases of severe wounds involving the bone and joints at the neck of the foot, we have been brought to follow the removal of the astragalus by a provisional turning back of the foot so as to permit the rapid and full disinfection of the articular surface which has been infected, and to prevent the retention of pus. The tibiotarsal articulations are widely opened on the two sides, sometimes on the external side only, and the foot is reversed either forward or inward, and held in this position by means of a bandage until complete disinfection has been accomplished. When the wound has been proven to be sufficiently sterile, the foot is brought back into good position and fixed by points of metallic suture. The final result of such an operation is satisfactory.

The tendency to equinus following a cicatricial retraction of the triceps of the calf, or loss of substance, requires elongation of the tendon of Achilles. Preventive measures are more important from this standpoint than curative, so the surgeon should take the greatest pains in wounds of the ankle to hold the foot at a right angle with the leg. The same should be said of the true equinus resulting from consolidation in a vicious position of the forefoot upon the tarsus, and more frequently of the anterior tarsus upon the posterior tarsus. Here again preventive treatment is more important than reparative treatment. Nevertheless, the process of cicatrization, notwithstanding the means used to prevent, may sometimes result in an equinus which must be remedied. In such cases most frequently cuneiform resection of the tarsus should be done. The operation consists in taking away from the tarsus a slice or a bony wedge extending to the soft parts of the plantar surface. The two cut surfaces are then brought together and held by metallic thread, followed by immediate suture of the operative wound.

EDITORIAL COMMENT

Irreparable destruction of the muscles of the anterior face of the leg, or of their tendons, leads equally to the development of equinus. In a case of this kind correction has been obtained by transplanting the tendons of the flexor longus of the great toe and of the peroneus longus on the other side of the foot. These muscles were divided at the level of the malleoli; their central ends were then brought to the anterior face of the leg and implanted into the peripheral ends of the tendons of the extensors and the anterior tibial, freed from the cicatricial mass in which they were engulfed.

Mobilization in Wounds of the Foot.—As a principle, there is much advantage in early mobilization of the foot. Long rest in bed leads always to muscular atrophy, articular stiffness, vicious positions and particularly to the equinus which in the majority of cases can be prevented by ordering the wounded man to arise as soon as his lesion will permit and directing appropriate movements. If the physician himself directs this reëducation, inspires confidence in the patient, criticizes his errors and methodically graduates the mobilization, surprising results can be arrived at. It should be noted, however, that early walking should be permitted only in cases where the important points of pressure have been preserved and where the solidity of the arch runs no risk of being compromised.

BOOK REVIEWS

AMBULANCE DE L'OCEAN, La Panne, Belgium. Scientific contributions published under the direction of Dr. A. DE PAGE, with the collaboration of Dr. A. P. DUSTIN and Dr. G. DEBAISIEUX, and of the physicians of the Hospital. Volume 2, Fasciculus 1, octavo, 352 pages, Masson & Co. Paris.

This attractive volume is a report of the work done at the Belgian army hospital at La Panne, under the direction of Dr. De Page. In the first volume, which appeared a year ago, a detailed description of the hospital and its methods of work was given. In the present volume the numerous articles contained in it constitute a review of the different branches of military medicine and surgery exemplified in the work of the hospital. The largest part is given up to experimental research and to the scientific control of various methods of treatment. This work is all the more notable since it has been carried on in close proximity to the battle line and in the midst of difficulties of every kind, of which bombardment was not the least.

Of the articles contained in this volume we present in the Department of Editorial Comment a very full resumé of memoirs: Article 1, by Dr. A. DE PAGE, *Le débridement des plaies de guerre*; Article 2, by Drs. DE PAGE and DELREZ, *Le traitement des plaies du pied*; Article 5, by Dr. CHARLES JANSSEN, *Le cranioplastie ses indications et sa technique*, and Article 9, by Dr. E. S. HARDE, *Frequence du bacille du tetanos*.

The volume as a whole is a valuable contribution to medical literature and to the records of scientific research, and demonstrates the possibilities of scientific enthusiasm added to methodical industry, even under most unfavorable circumstances. We hope that it may be the harbinger of many similar publications in the immediate future which may present to the surgical profession the riches which the experience of the four years of warfare has accumulated in the hospitals of the Allied forces.

OXFORD LOOSE-LEAF SURGERY. By various authors. Edited by F. F. BURGHARD, Lecturer on Surgery, King's College Hospital, London, and ALLEN B. KANAVAL, Associate Professor of Surgery, Northwestern University Medical School, of Chicago. In five volumes. Volume I, 1918. New York. Oxford University Press. Octavo, buckram, loose-leaf, 971 pages.

The publishers present to the profession a novelty in book-making, a book in which the cover is fastened to the main body of the volume by a mechanism which makes it possible to remove the covers and insert additional leaves. Special attention is called to this feature of this particular book. It will be of interest to see whether actual experience shall prove that practically it presents any marked advantage. The volume now before us is one of nearly a thousand pages of supercalendered paper abundantly illustrated and forming a volume quite as large as can be conveniently handled. Should any additions or changes in the chapters included in such a volume be desired, as will certainly be the case, it is probable that they will still have to be incorporated in supplementary volumes notwithstanding this loose-leaf mechanism. This, however, in no wise has to do with the originality and individuality which the main body of the volume presents.

The attention of future medical bibliophile, in looking over the list of contributions to the present volume, will be attracted by the fact that so many of them present military titles indicative of their active participation in military work. This first volume appears while the whole world is rejoicing in the end of the great war and when the dawn of permanent and universal peace has apparently already made its appearance, so that it is profoundly to be hoped that much of the discussions and special methods demanded by the special conditions, which have attended the wounds of the last four years sustained in the battlefields of Belgium and France, will no longer have any important relation, but will remain as matters of historical interest only.

The present set of volumes is a development of the "Manual of Surgical Treatment," by Cheyne and Burghard, the scope and character of which have received repeated notice in reviews in this journal as the volumes have appeared from time to time. To this, however, have been added various contributions from American clinics and such revisions as have been called for by the development in surgical practice produced by experience in war.

It is quite evident that the attempt of the authors has been to confine its contents to procedures which are of actual present importance.

The volume is especially to be commended for its typographical qualities, the size of the type and its general manner of composition are such as to make it easy to read even by the tired eyes of a senior surgeon, while the illustrations are exceedingly well done. It is, indeed, difficult to select from among the large number of illustrations any group for particular mention, but those which illustrate the various forms of amputations practiced upon the foot are a fair sample.

One who desires to acquaint himself with the newer surgery will be especially interested in the chapter by Major Penhallow, of the Massachusetts National Guard, on the Treatment of Infected Wounds by the Carrel Method, and by that of Dr. Percy, of Chicago, and Lewisohn, of New York, on Blood Transfusion. Every department, however, is thoroughly up to date and, if the present volume is an indication of those which are to follow, it will be a series of volumes that no active surgeon can afford to be without.

THYROID AND THYMUS. By ANDRÈ CROTTI, M.D., of Columbus, Ohio.
Large octavo; pages 567; profusely illustrated, Philadelphia and New York: Lea & Febiger, 1918.

This is an intensive study in goitre pathology and surgery; a monograph which has had its origin in an enthusiastic devotion to its subject. In it are embodied the results of experiences and observations made in the laboratory of Stilling of Lausanne, and in the clinic of Kocher in Berne. In a very considerable degree it may be accepted as a presentation of the teachings of those masters.

The typographical setting of the monograph is most attractive and the large number of illustrations form a marked feature of the book. The anatomical drawings, many of them in color, are by Marcel Guelin.

The anatomy, physiology, biological chemistry and pathology of the thyroid each have their respective chapters. Every aspect of goitre is elaborately studied. It evidently has been the author's plan to make his study a full record of everything of value which has been contributed to the subject by any worker anywhere. The French, Italian and German literature have been thoroughly sifted.

The presentation of the result of this study is by no means a dry and

BOOK REVIEWS

elaborate citation of quotations; but everything has been happily transformed in the alembic of the author's own mind into a clear, interesting and connected presentation of his conclusions.

We are glad to have this full and complete study of the thyroid and thymus to place upon our shelf as a book of reference.

UNITED STATES ARMY X-RAY MANUAL. Authorized by the Surgeon-General of the Army. Prepared under the direction of the Division of Röntgenology. 12mo, flexible covers, 506 pages. New York: Paul B. Hoeber, 1918.

This manual is one of many publications which have emanated from the office of the Surgeon-General of the Army since the entrance of the United States into the great war, results of the comprehensive plans laid to secure the highest possible efficiency for the Medical Department of the Army: plans which are worthy of the highest commendation and which have played a very large part in securing the extraordinary immunity from disease which has marked the history of the American Expeditionary Force in France, and the ideal results in the treatment of the wounded which its statistics demonstrate. The manual under review is intended as a guide to röntgenologists who are doing the X-ray work in the United States military hospitals, and as a text-book of instruction in military röntgenology. The elaborateness and completeness of the X-ray plants which have been placed in all the base hospitals and in many of the evacuating stations have been a marked element in the hospital administration of this government and have been an important element in securing the successful results noted.

The importance of a book of this kind for training and guiding the work of the large number of röntgenologists required for the work of our army hospitals is self-evident. Into this work there must have been commandeered many men who had little or no previous experience in that class of work. In preparing such men for their work, and as a book of reference in their later active work, this manual will be of very great value. Particularly in the department of the localization of foreign bodies does the work of the röntgenologist assume importance in the hospitals upon the advanced line.

The chapters in this manual devoted to fluoroscopy and to the best apparatus for the localization of foreign bodies are especially worthy of

BOOK REVIEWS

remark. The chapters devoted to bones and joints also are clear and of especial importance in acute military surgery.

The X-ray has established itself as an important auxiliary in all surgery and in general medicine. While the present manual will be placed in the hands of all surgeons holding commissions from the government, it is equally valuable to the general surgeon in civil practice in assisting him in securing the best results in the ordinary surgery of civil life.

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No. 2

STUDIES IN BONE TRANSPLANTATION; A STUDY OF A METHOD OF INCREASING THE OSTEOGENETIC POWER OF A FREE BONE TRANSPLANT

By BARNEY BROOKS, M.D.

WITH THE COLLABORATION OF PAUL FUNKHOUSER, O. S. KREBS, AND F. C. HOWARD
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ST. LOUIS, MISSOURI

In a series of experiments, which have already been reported,¹ it was shown that sodium alizarine sulphonate is a specific vital stain for growing bone. If a solution of this dye is injected intraperitoneally into animals at repeated intervals all bone which is formed during the period of the injections is stained a bright red color. This experimental method makes it possible to observe accurately the site and the amount of all new bone formed during any given period of time.

In a second series of experiments, also previously reported,² in which this method of study was used, it was found that the power of regeneration of new bone was limited to the periosteal and endosteal surfaces of the free living bone transplant. If the periosteal and endosteal surfaces of the transplant were completely removed, no bone grew from the transplant.

It was further observed in these experiments that in certain instances autogenous bone transplants with periosteum and endosteum failed to regenerate bone. All such instances were experiments in which old animals were used. It was stated that the power of regeneration of bone in a free bone transplant varies with the age of the individual, and that free transplants of bone result in a considerable proportion of failures if old animals are used.

The object of the experiments described in this paper was to test the value of a method of increasing the osteogenetic power of the autogenous bone transplant, in order that a defect in the shaft of a bone of an old animal could be bridged by a free bone transplant with a better prospect of the ultimate successful regeneration of the defect.

EXPERIMENTAL METHOD

Dogs were used as experimental animals. The oldest animals available were used. Before beginning each experiment the age of the dog was estimated by observing the state of preservation of the teeth, and the general

¹ Brooks: ANNALS OF SURGERY, June, 1917.

² Brooks: ANNALS OF SURGERY, Dec., 1917.

appearance and activity of the animal. It was possible at the end of each experiment to estimate the age of the animal more accurately by observing the relation of the epiphyses and the diaphyses of the long bones. This examination at least makes it possible to classify dogs according to age into young, adult and old. The presence of the epiphysial cartilage shows definitely that the dog is a young animal. No such animal was used in these experiments. In some of the dogs of these experiments it was observed that all traces of the junctions of the diaphyses and epiphyses were absent and the bones were hard and brittle. These instances were considered as old animals. In a few instances it was observed that although the epiphysial cartilages were completely absent the junctions of the epiphyses and diaphyses were plainly marked. Such animals were considered as adult dogs not particularly old. The use of the vital stain also made it possible to estimate the ages of the animals. The administration of this dye to young animals results in the staining of all bones of the body, while in the case of animals which have reached the age in which active growth of the bones has ceased, no such general staining of the bones takes place. In these experiments there was in no instance general staining of the bones by the vital stain.

The operative procedure was the same in all experiments except in a few details which will be indicated in the description of the individual experiments. Each animal had two operations, which for purpose of clearness will be referred to as "first stage" and "second stage" operation.

The first stage operation was as follows: After the usual skin preparation an incision was made in the lateral surface of the left thigh and the shaft of the femur was exposed. With a motor twin saw parallel incisions 4 mm. apart and 6 cm. long were made through the cortex of the shaft of the femur. Great care was taken not to strip away the periosteum between the saw cuts. The wound was then carefully closed. The skin sutures were removed on the third day after operation.

The second stage operation was in most instances done on the seventh day after the first stage operation. The animal was again anæsthetized and the skin of both forelegs and both thighs was prepared for operation. Incisions were then made in both forelegs and 4 cm. of the shaft of each ulna was resected. Great care was used to remove the sections of bone with all the periosteum. This can be done easily if the interosseus membrane between the ulna and radius is divided before beginning the resection of the ulna.

The wound in the left thigh was then opened and the femur exposed. Transverse saw cuts were made in the shaft of the femur at the ends of the parallel incisions which had been made at the previous operation. The bone transplant was then easily freed with a knife. The transplant showed marked thickening of the periosteum and there was evident new bone formation along the periosteal and endosteal surfaces. This transplant was used to bridge the defect in the left ulna.

An incision was then made in the right thigh and the femur exposed.

With a motor twin saw another transplant 4 mm. wide and 6 cm. long was removed from the shaft of the right femur which had not been subjected to previous operative injury. Great care was used not to strip away the periosteum from the transplant. This transplant was used to bridge the defect in the right ulna.

All wounds were closed. Both forelegs were dressed with plaster dressings.

Beginning on the 14th day after the second operation, the animals were given intraperitoneal injections of 3 cc. of a 5 per cent. solution of sodium alizarine sulphonate twice each week until the end of the experiments. The animals were sacrificed at the end of periods of 23 to 173 days after the second operation, and bones of the extremities removed for study.

This experimental method gave in each experiment two free bone transplants which were used to bridge similar defects in the shafts of the bones of an old animal. The transplant which was used to bridge the defect in the right ulna was cut from a bone in its normal quiescent state. The transplant which was used to bridge the defect in the left ulna was removed from a bone which was producing new bone in response to previous injury. Stated from another viewpoint, the transplant which was used to bridge the defect in the left ulna was partially cut in such manner as not to interfere with its nutrition and left *in situ* until it began to grow and then transplanted. The defect in the right ulna was bridged by a graft which was then not in a state of active growth.

The use of the vital stain made it possible to determine the site and amount of all new bone formed from the transplants.

In all experiments, the operative procedures were carried out with the animal in complete surgical anæsthesia. Careful aseptic technic was used. In all experiments included in this paper, the wounds healed without infection. Every effort was made to prevent pain and suffering in the experimental animal. In three instances wound infection followed operation. In two experiments fracture of the femur followed the operation. These animals were sacrificed immediately. In three other experiments the animals died of pneumonia before sufficient time had elapsed after operation to make the experiment of value. All animals were sacrificed by the administration of chloroform.

EXPERIMENTS

Experiment No. 30.—Dog No. 35.—July 8, 1918.

Apparently old animal. Weight 10.5 K. First stage operation on left femur.

July 15, 1918, 7 days, second stage operation. Transplant from left femur used to bridge defect in left ulna. Transplant from right femur used to bridge defect in right ulna.

August 7, 1918, 23 days, dog died of general peritonitis following intraperitoneal injections of vital stain.

Examination of the bones indicated that the animal was an old dog.

All epiphyses united. All traces of epiphysial lines had disappeared. No general staining of bones by vital stain.

Left foreleg: Transplant in good position. Firmly united to stumps of resected bone by fibro-cartilaginous callus. There was a large amount of new bone formed along the entire endosteal and periosteal surfaces of the transplant. There was also new bone formed from the stumps of the resected bone and under the periosteum of the radius in the region of operation.

Right foreleg: Transplant in good position. Graft lay loosely in the surrounding tissues. Evidently entirely necrotic. No bone growth from the transplant (Plate I, Fig. 1).

Experiment No. 29.—Dog No. 56.—July 6, 1918.

Apparently old dog. Teeth worn. Gray hairs about mouth. Weight 10 K. First stage operation on left femur.

July 13, 1918, seven days, second stage operation. Transplant from left femur used to bridge defect in left ulna. Graft from right femur used for defect in right ulna.

August 9, 1918, twenty-seven days, dog died from anæsthetic during injection of vital stain.

Examination of bones indicated that the dog was an old animal. All epiphyses united and all traces of epiphysial lines had disappeared. No general staining of bones by the vital stain.

Left foreleg: Transplant in good position. Bone growing along the entire endosteal surface of the transplant. Small nodule of new bone on periosteal surface near middle of graft.

Right foreleg: Transplant in good position. There was a small island of new bone on the periosteal surface of transplant near its proximal end. No other bone growth from the graft (Plate I, Fig. 2).

Experiment No. 38.—Dog No. 83.—July 12, 1918.

Apparently old dog. Gray about mouth. Teeth worn. Weight 12 K. First stage operation on left femur.

July 20, 1918, eight days, second stage operation. Transplant from left femur used to bridge defect in left ulna. Transplant from right femur used for defect in right ulna.

August 20, 1918, thirty-one days, dog dead of abscess in peritoneum following injection of vital stain.

Examination of the bones indicated that the animal was an old dog. All traces of the junctions of the epiphyses and diaphyses had disappeared. The bones were brittle. There was no general staining of the bones by the vital stain.

Left foreleg: The transplant was in good condition. It was united to the stumps of the resected ulna. There was new bone formation along the entire endosteal surface of the transplant. There was a nodule of new bone on the periosteal surface near the middle of the transplant.

Right foreleg: The transplant was in good position. There was no evidence of growth of bone from any part of the transplant (Plate I, Fig. 3).

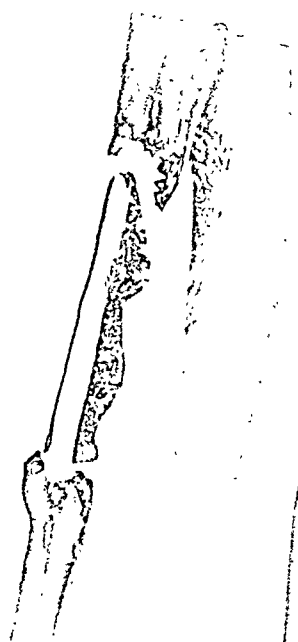
Experiment No. 21.—Dog No. 8.—June 24, 1918.

Left

FIG. 1

PLATE I

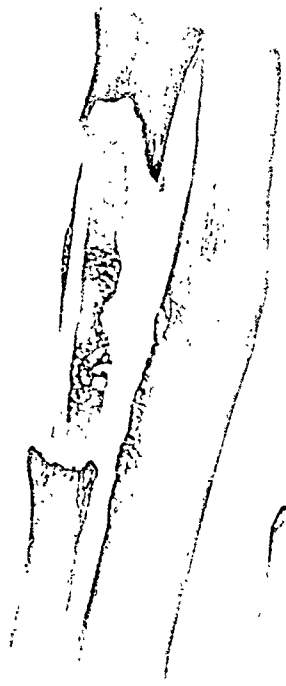
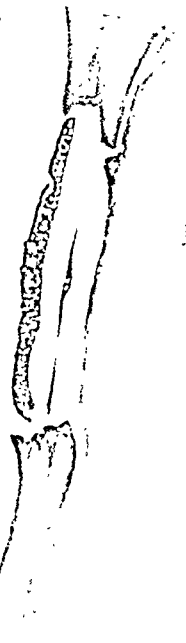
Right



Left

FIG. 2

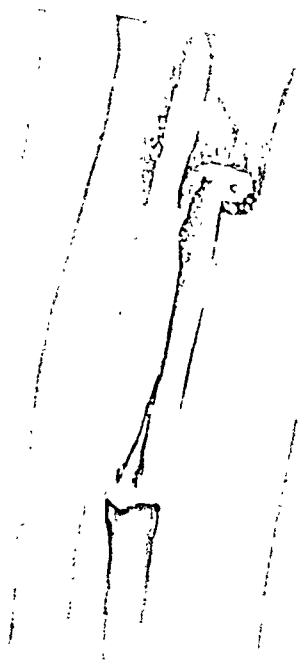
Right



Left

FIG. 3

Right



Left

FIG. 4

Right

Apparently adult dog. Did not appear old. Teeth good. Weight 5.5 K. First stage operation on left femur.

July 1, 1918, seven days, second stage operation. Transplant from left femur used to bridge defect in left ulna. Transplant from right femur used for defect in right ulna.

August 6, 1918, thirty-seven days, animal died from anæsthetic while receiving injection of vital stain.

Examination of the bones indicated that the animal was an old dog. The junction of the diaphyses and the epiphyses were not visible. There was no general staining of the bones by the vital dye.

Left foreleg: Transplant was in good position. It was united to the stumps of the resected bone. There was new bone formation along the entire endosteal and periosteal surfaces of the transplant.

Right foreleg: Transplant in good position. United to the stumps of the resected bone. Bone growth along the entire endosteal surface of the transplant. Small islands of new bone formation along the periosteal surface.

The amount of new bone formed from the transplant in the defect in the right ulna was less than that formed from the transplant in the defect in the left ulna (Plate I, Fig. 4).

Experiment No. 4.—Dog No. 11.—April 4, 1918.

Animal apparently adult animal. Does not seem old. First stage operation on right femur.

April 25, 1918, twenty-one days, second stage operation. Transplant from right femur used to bridge defect in right ulna. Graft from left femur used for defect in left ulna.

June 4, 1918, forty days, animal did not have injections of vital stain.

Examination of the bones indicated that the animal was an adult dog. All epiphysial cartilages had disappeared, but the junctions of the epiphyses and diaphyses could be plainly seen.

Right foreleg: Transplant in good position. Firmly united to the stumps of the resected bone. Distinct bone growth along the entire transplant.

Left foreleg: Transplant in good position. Firmly united to the stumps of the resected bone. There was new bone formation along the entire length of the transplant.

There was no noticeable difference in the amount of bone formed by the two transplants.

Experiment No. 15.—Dog No. 61.—June 19, 1918.

Apparently old dog. Teeth worn. Weight 7 K. First stage operation on left femur.

June 26, 1918, seven days, second stage operation. Transplant from left femur used to bridge defect in left ulna. Graft from right femur used for defect in right ulna.

August 23, 1918, fifty-eight days, dog emaciated. Sacrificed.

Examination of the bones indicated that the animal was an old dog. All traces of the epiphysial lines had disappeared. There was no general staining of the bones by the vital dye.

Left foreleg: The transplant was in good position. It was firmly united by bone to the stumps of the resected ulna. There was bone growth along the entire length of the graft.

Right foreleg: The transplant was in good position. It was united to the distal stump of the ulna by bone and to the proximal stump of the ulna by fibrous tissue. There was growth of bone along the entire length of the transplant. The amount of new bone formed from the transplant was distinctly less than that formed from the transplant in the defect of the left ulna (Plate II, Fig. 6).

Experiment No. 1.—Dog No. 47.—February 27, 1918.

Apparently old dog. First stage operations on left femur.

March 18, 1918, nineteen days, second stage operation. Transplant from left femur used to bridge defect in left ulna. Graft from right femur used for defect in right ulna.

May 20, 1918, sixty-three days, animal in good condition. Sacrificed.

Examination of bones indicated that the animal was an old dog. All traces of the junctions between epiphyses and diaphyses had disappeared. Bones brittle. No general staining of bones by vital stain.

Left foreleg: The transplant was in good position. Graft firmly united to the stumps of the resected ulna. There is abundant growth of new bone along the entire length of the transplant.

Right foreleg: The transplant was in good position. It was not united to the stumps of the resected bone. There was no growth of bone from the transplant (Plate II, Fig. 5).

Experiment No. 39.—Dog No. 84.—July 12, 1918.

Apparently adult dog. Does not seem old. Teeth well preserved. Weight 14 K. First stage operation on left femur.

July 19, 1918, seven days, second stage operation. Transplant from left femur used to bridge defect in left ulna. Transplant from right femur used for defect in right ulna.

September 22, 1918, sixty-four days, dog dead of unknown cause.

Examination of the long bones showed all epiphyses united. There was no general staining of the bones by the vital stain.

Left foreleg: The transplant was in good position. It was united firmly to the stumps of the resected ulna. There was a large amount of new formed bone along the entire endosteal surface. There was also growth of bone along the periosteal surface.

Right foreleg: The transplant was in good position. It was loosely united to the stumps of the resected ulna by fibrous tissue. The transplant was about half its original size. All surfaces were rough. There was a small nodule of new bone at the middle of the transplant. It was not possible to distinguish the periosteal and endosteal surfaces of the transplant. There was such a small amount of growth of bone from the graft that it seemed unlikely that the defect would have ultimately been regenerated.

Experiment No. 3.—Dog No. 61.—March 20, 1918.

Apparently old dog. First stage operation on left femur.

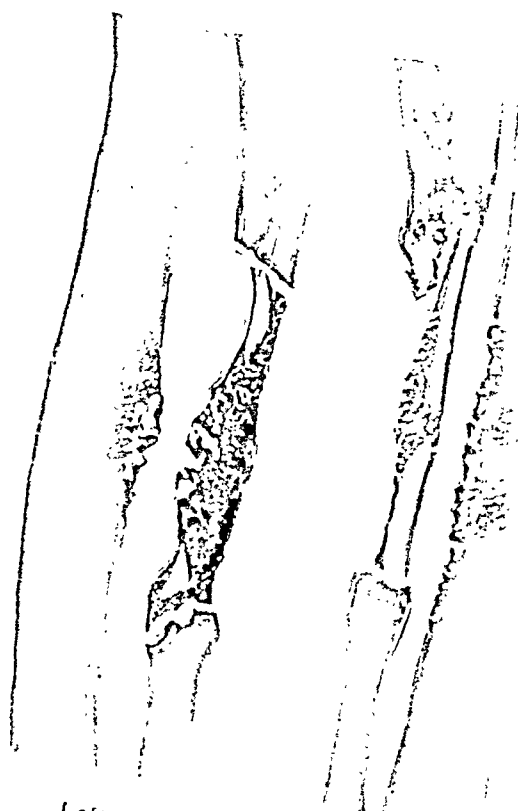
April 4, 1918, thirteen days, second stage operation. Transplant

PLATE II

FIG. 5

Left

Right



Left

Right

FIG. 6

STUDIES IN BONE TRANSPLANTATION

from left femur used to bridge defect in left ulna. Transplant from right femur used for defect in right ulna.

June 5, 1918, sixty-five days, animal in good condition. Did not have injections of vital stain.

Examination of the long bones shows all epiphyses united. The junctions of the epiphyses and diaphyses were not visible.

Left foreleg: The transplant was in good position. It was firmly united to the stumps of the resected ulna. There was growth of bone along the entire transplant.

Right foreleg: The transplant was in good position. There was growth of bone along the entire transplant.

There was no apparent difference in the results of the two transplants.

Experiment No. 2.—Dog No. 88.—February 27, 1918.

Apparently old dog. First stage operation on right femur.

March 28, 1918, twenty-nine days, second stage operation. Transplant from right femur used to bridge defect in right ulna. Transplant from left femur used for defect in right ulna.

June 5, 1918, sixty-nine days, animal in good condition. Sacrificed.

Examination of the bones showed all epiphyses united and the junctions of epiphyses and diaphyses were not visible. There was no general staining of the bones by the vital stain.

Right foreleg: The transplant was in good position. It was firmly united to the stumps of the resected ulna. There was growth of bone along the entire length of the transplant.

Left foreleg: The transplant was in good position. It was firmly united to the stumps of the resected ulna. There was growth of bone along the entire length of the transplant. The amount of new bone formed, however, was distinctly less than that formed from the transplant in the defect in the right ulna.

Experiment No. 42.—Dog No. 87.—July 26, 1918.

Apparently adult dog. Did not appear old. Teeth well preserved. First stage operation on left femur.

August 6, 1918, eleven days, second stage operation. Defect in left ulna bridged with transplant from left femur. Transplant from right femur used for defect in right ulna.

October 29, 1918, seventy-nine days, animal in good condition. Sacrificed.

Examination of bones showed all epiphyses united and all traces of the junctions of epiphyses and diaphyses absent. No general staining of bones by vital stain.

Left foreleg: The transplant was in good position. It was firmly united to the stumps of the resected bone. There was growth of bone along the entire endosteal and periosteal surfaces of the transplant.

Right foreleg: The transplant was not in good position. The distal end of the transplant was united to the distal stump of the resected ulna. The proximal end of the transplant was displaced so that it lay in contact with the radius. Along the proximal half of the transplant there was a large amount of new formed bone which was continuous

with new bone which had grown from the shaft of the radius. The distal end of the transplant showed much less new bone formation.

There was a larger amount of bone growth in the defect in the right ulna than was present in the defect in the left ulna.

Experiment No. 41.—Dog No. 86.—July 26, 1918.

Apparently old dog. Teeth worn. Weight 11 K. First stage operation on left femur.

August 2, 1918, seven days, second stage operation. Defect in left ulna bridged with transplant from left femur. Transplant from right femur used for defect in right ulna.

November 8, 1918, ninety-four days, animal in good condition. Sacrificed.

Examination of the bones indicated that the animal was an old dog. All traces of the junctions of the epiphyses and diaphyses absent. No general staining of the bones by the vital stain.

Left foreleg: Transplant in good position. Firmly united to the stumps of the resected bone. There was growth of bone along the entire length of the transplant.

Right foreleg: The transplant was in good position. It was united to the stumps of the resected bone. The transplant was much smaller than at the time of transplantation. There was growth of new bone at both extremities of the graft. There was distinctly less growth of bone from the transplant in the defect in right ulna than from the transplant in the defect in the left ulna.

Experiment No. 32.—Dog No. 77.—July 9, 1918.

Large adult male. Did not seem particularly old. Weight 13.5 K. First stage operation on left femur.

July 16, 1918, seven days, second stage operation. Defect in left ulna bridged with transplant from left femur. Transplant from right femur used for defect in right ulna.

October 29, 1918, one hundred and five days, animal in good condition. Sacrificed.

Examination of bones showed all epiphyses united. There was no general staining of bones by the vital stain. The junctions of diaphyses and epiphyses faintly visible.

Left foreleg: Transplant in good position. Firmly united to the stumps of the resected ulna. There was growth of bone along the entire endosteal surface of the transplant. Also a small nodule of new bone formation on the periosteal surface near the middle of the transplant.

Right foreleg: Transplant in good position. United to the stumps of the ulna. There was growth of bone from the endosteal surface of the entire length of the transplant. There was a small amount of new formed bone on the periosteal surface at the ends of the transplant.

Experiment No. 33.—Dog No. 78.—July 9, 1918.

Apparently old dog. Teeth worn. Weight 11.5 K. First stage operation on left femur.

July 17, 1918, eight days, second stage operation. Defect in left

ulna bridged with transplant from left femur. Transplant from right femur used for defect in right ulna.

October 29, 1918, one hundred and five days, animal in good condition. Sacrificed.

Examination of bones indicated that animal was an adult dog. All epiphyses united. The junctions of the epiphyses and the diaphyses were fairly distinct. No general staining of the bones by the vital stain.

Left foreleg: The transplant was in good position. It was firmly united to the stumps of the resected ulna. There was growth of bone along the entire transplant.

Right foreleg: The transplant was in good position. It was firmly united to the stumps of the ulna. There was bone growth along the entire length of the transplant. The amount of new bone formed was less than that formed from the transplant in the defect in the left ulna. *Experiment No. 19.*—Dog No. 88.—June 22, 1918.

Large adult dog. Did not appear particularly old. Weight 10.5 K. First stage operation on left femur.

June 29, 1918, seven days, second stage operation. Defect in left ulna bridged with transplant from left femur. Transplant from right femur used for defect in right ulna.

October 22, 1918, one hundred and fifteen days, dog emaciated. Has mange. Sacrificed.

Examination of bones showed that animal was an adult dog. There was slight general staining of the metaphyses of all the long bones. The epiphysial cartilages were absent. The junction of the epiphyses and diaphyses was plainly visible.

Left foreleg: The transplant was completely absorbed. There is new bone formation at the ends of the stumps of the ulna. No growth of bone in the defect.

Right foreleg: The transplant had entirely disappeared. No bone in the defect.

Experiment No. 31.—Dog No. 76.—July 8, 1918.

Apparently moderately old dog. Weight 9.5 K. First stage operation on left femur.

July 15, 1918, seven days, second stage operation. Defect in left ulna bridged with transplant from left femur. Transplant from right femur used for defect in right ulna.

November 8, 1918, one hundred and sixteen days, dog in good condition. Sacrificed.

Examination of bones showed all epiphyses united. Lines of junctions of epiphyses and diaphyses almost but not completely obliterated. No general staining of bones by vital stain.

Left foreleg: Transplant in good position. Firmly united to stumps of ulna. Bone growth along entire length of graft.

Right foreleg: Transplant in good position. Firmly united to distal stump of ulna. Loosely united to proximal stump by fibrous tissue. Only a thin piece of the original transplant remained. There is a small

BARNEY BROOKS

amount of new bone formation from the transplant. The distal stump of the resected ulna was markedly atrophied.

Experiment No. 5.—Dog No. 73.—April 24, 1918.

Apparently adult dog. First stage operation on right femur.

May 6, 1918, twelve days, second stage operation. Defect in right ulna bridged by transplant from right femur. Transplant from left femur used for defect in left ulna.

October 14, 1918, one hundred and seventy-three days, animal in good condition. Was not given injections of vital stain. Sacrificed.

Examination of the bones indicated that the animal was an adult dog. Epiphyses united. The junctions of the epiphyses and diaphyses, however, were still well defined.

Right foreleg: Defect in the ulna completely regenerated.

Left foreleg: Defect in the ulna completely regenerated.

There was no noticeable difference in the results of the two bone transplants.

RESULTS

In each of these experiments two bone transplants were used. One transplant was cut from a bone in its normal state. The other transplant

Experiment No.	Days between first stage operation and second stage operation.	Days from second stage operation to end of experiment.	Result of ordinary bone transplant. + Successful. 0 Failure. ? Doubtful success.	Result of growing bone transplant. + Successful. 0 Failure. ? Doubtful success.	Estimated age of animal.	Remarks.
30	7	23	0	+	Old	
29	7	27	?	+	Old	
38	8	31	0	+	Old	
21	7	37	+	+	Old	More bone formed from growing bone transplant.
4	21	40	+	+	Adult	No difference in results of two transplants.
15	7	58	+	+	Old	More bone formed from growing bone transplant.
1	19	63	0	+	Old	
39	7	64	0	+	Old	
3	13	65	+	+	Old	No difference in results of two transplants.
2	29	69	+	+	Old	More bone formed from growing bone transplant.
42	11	79	+	+	Old	See discussion.
41	7	94	+	+	Old	More bone formed from growing bone transplant.
32	7	105	+	+	Adult	No difference in results of two transplants.
33	8	105	+	+	Adult	More bone formed from growing bone transplant.
19	7	115	0	0	Adult	See discussion.
31	7	116	?	+	Adult	
5	12	173	+	+	Adult	No difference in results of two grafts.

STUDIES IN BONE TRANSPLANTATION

Type of bone transplant	Number of experiments	Successful		Doubtful success		Failure	
		No.	Per cent.	No.	Per cent.	No.	Per cent.
Ordinary transplant.....	17	10	58.8	2	11.7	5	29.3
Growing bone transplant.....	17	16	94.1	0	0	1	5.8

was cut from a bone which was producing new bone in response to a previous injury. The two types of transplants were made simultaneously under the same conditions in the same animal, and the results studied at the end of the same period. The results of the two types of transplants are summarized in the following tables:

DISCUSSION

These experiments are interesting in that they show a relatively large proportion of instances in which the ordinary bone transplant with periosteum and endosteum failed to regenerate a bone defect when the transplantations were made in animals which were not young. In many other experiments not included in this study it has been found that similar transplants of bone in young animals have been successful in almost every instance in which there was not some obvious reason, such as infection, for their failure. The experiments are particularly interesting in that they show that transplants of growing bone result in a much larger proportion of successes than the normal bone transplants.

The success or failure of a bone transplant obviously must be determined by both internal and external factors. The latent power of the osteoblasts to multiply and produce bone is an internal factor and would seem to depend on the intrinsic latent power of regeneration of the bone from which the transplant is taken. The adequate supply of nutrition for growth of the bone-producing cells must come from the bed into which the transplant is placed and is an external factor. There are also more complicated external factors which at present are not clear and the nature of which is suggested by the more or less indefinite terms, "functional demand," "stimulus to growth," "immunity of tissues."

Whether the failure of a relatively large proportion of free bone transplants in old animals is the result of internal or external factors is not clear. It would seem most probable, however, that it was the result of the low intrinsic osteogenetic power of the bones in advanced life. It is possible that further experiments with homogenous transplants from young to old and from old to young animals would answer this question. It is also not clear from these experiments whether the growing bone transplant is successful in a larger proportion of instances than the normal bone transplant, because it contains cells with greater power of growth or because the growing tissue with its numerous thin-walled vessels and tissue spaces more readily acquires nutrition from the bed in which the transplant is placed. It would

seem more likely that the latter is true. If this is so, then the transplants would possibly succeed in even a larger proportion of instances if the bed into which the transplant is to be placed were also stimulated to grow by previous operative procedure. Further experiments are necessary to determine this point.

Experiment No. 19 deserves special comment. In this experiment the animal was not particularly old. The transplantations were done with apparently the same technic as in other experiments. The operative wounds healed without any evidence of infection. Both types of transplants completely failed to show any evidence of bone regeneration, and the original transplanted bone was completely absorbed at the end of one hundred and fifteen days. The general condition of the animal was not the best as was shown by the mangy skin, yet in other animals this condition has not seemed to influence bone regeneration. It is possible that this animal is comparable to certain clinical cases in whom there is almost complete lack of regenerative power of the bones.

The results of these experiments have a particular bearing on the clinical treatment of a certain group of non-united fractures. In some instances fractures do not unite as a result of poor approximation of the fragments. In such cases there is not necessarily poor regenerative power in the fractured bone and union may follow the correct approximation of the fragments of the fractured bone. In other instances, however, there is non-union in spite of good approximation of the fragments. In such instances, the failure of the fracture to unite must be the result of poor regenerative power in bone. The results of these experiments bear particularly on the latter group of cases.

The method of treatment of such cases at present consists in the use of a free bone transplant to bridge the fracture. The bone transplant may be removed from one of the fragments and placed across the defect, *i.e.*, the so-called sliding bone graft, or the transplant may be taken from another bone. In the sliding bone graft method the transplant is certainly removed from a bone which has little power of regeneration. From these experiments it would seem, therefore, that such a transplant would have correspondingly little osteogenetic power and would fail in a considerable proportion of instances to regenerate bone to unite the fracture. We believe this statement is borne out by clinical experience with the application of this method. As regards the method of removing the transplant from another bone, we have seen, clinically, instances in which it seemed that the failure to regenerate bone was a condition not limited to bone in which the fracture failed to unite but was common to all the bones.

In these experiments in which only dogs well advanced in life were used and in which the bones showed power of regeneration less than that in young animals, the conditions were comparable to those existing in clinical cases of non-union of fracture as a result of poor regenerative power in the bones. The method of using transplants of growing bone resulted in so much larger

a proportion of successful results than those following the use of normal bone transplants that it would seem as if the clinical use of this method would be valuable.

Experiments similar to these with other tissues have been reported by Loeb. Loeb found that transplants of regenerating kidney tissue in the rabbit resulted in more extensive growth than transplants of non-regenerating kidney.³ In other experiments, however, this investigator found that transplants of regenerating epithelium did not grow more extensively than transplants of non-regenerating epithelium.⁴

These experiments are interesting in relation to other experiments now in progress. It has been found that a defect in the bone of an old animal can be successfully repaired by bridging the defect with a homogenous transplant of bone taken from a young animal. Further experiments are in progress to determine the relative value of this method as compared with the method described in this paper.

In these experiments the growing bone transplants have been transplanted seven to twenty-nine days after stimulating growth. In other experiments not yet completed the period between the first stage operation and the second stage operation has been varied. It is probable that the chance of success of the graft depends on the length of this period. The determination of the relative power of the bone callus in its successive stages of growth and atrophy to further regenerate bone has an important bearing on the treatment of all fractures.

In conclusion I wish to thank Mr. E. H. Hashinger of the senior class of the Washington University Medical School for the illustrations of this paper.

CONCLUSIONS

1. Autogenous transplants of normal bone with periosteum and endosteum fail to regenerate successfully defects in bone in relatively large proportion of instances if such transplantations are done in animals well advanced in life.

2. Autogenous transplants of growing bone succeed in a much larger proportion of instances than autogenous transplants of bone not in the state of active growth or regeneration.

EXPLANATION OF PLATES

In all of the illustrations the bone which was regenerated during the period of the experiment is colored red. The results of the growing bone transplants are shown in the drawings of the bones of the left forelegs. The results of the normal bone transplants in the same animals are shown in the drawings of the bones of the right forelegs.

³ Loeb: *Anat. Record*, 1912, vi, 109.

⁴ Loeb: *Arch. f. Endwicklungs-mechanic d. Organism*, 1917, xxiv, 638.

BARNEY BROOKS

PLATE I.

Figure 1. Experiment No. 30. Twenty-three days. Showing complete failure of normal bone graft in right ulna. Large amount of bone regeneration from growing bone transplant in left ulna.

Figure 2. Experiment No. 29. Twenty-seven days. Showing small island of new bone on normal bone graft in right ulna. Abundant bone growth from growing bone transplant in left ulna.

Figure 3. Experiment No. 38. Thirty-one days. Showing bone regeneration from growing bone transplant in left ulna. No regeneration of bone from normal bone transplant in right ulna.

Figure 4. Experiment No. 21. Forty days. Showing regeneration from both types of transplants. More bone growth from growing bone transplant in left ulna.

PLATE II.

Figure 5. Experiment No. 1. Sixty-three days. Showing complete failure of the normal bone transplant in the defect in the right ulna. Complete regeneration of the defect in the left ulna as a result of the growing bone transplant.

Figure 6. Experiment No. 15. Fifty-eight days. Showing regeneration of bone from both types of transplants. More extensive growth from the growing bone transplant in the left ulna.

THE ADVANTAGES OF PICRIC ACID OVER TINCTURE OF IODINE FOR DISINFECTION OF SKIN

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IN 1910 I read a paper before the New York Surgical Society on "Disinfection of the Skin by Tincture of Iodine."¹ This paper was based on a year's trial of the method, and the results obtained seemed to justify the claims of Grossisch for its employment. My paper stimulated a good deal of interest, certainly in local circles, and perhaps had something to do with the general adoption of the method.

Soon after the publication of the paper I had several cases in which the iodine produced very disagreeable caustic effects; so much so, that for a time I abandoned it. The asepsis resulting from the return to the former methods was disappointing by contrast and I subsequently resumed the use of tincture of iodine, being careful, however, to wash off the iodine with alcohol, at the end of the operation. This modification on the whole was satisfactory, and the caustic effect of the iodine was diminished. Cases, however, did occur which gave rise to a good deal of annoyance, and I have long been on the lookout for some other suitable agent.

While stationed at a British Casualty Clearing Station, in 1917, I became familiar with the use of picric acid, 5 per cent. alcoholic solution, as a substitute for tincture of iodine. The wounds did fully as well as with tincture of iodine. I saw no cases of irritation of the skin and I was assured by everyone that none ever developed. The method has for some time been the routine mode of disinfection of the skin in the British armies.

In my service at the New York Hospital I have only tried it out in about one hundred consecutive cases, but we are exceedingly pleased with it. In no case has any patient manifested the slightest tendency to skin irritation or evidence of any discomfort. I am firmly convinced that we have in this solution an agent which should replace tincture of iodine entirely, as it has all of its advantages and none of its drawbacks. It is also very cheap. Prior to its use on the operating table the skin can be shaved with soap lather and scrubbed with soap and water as much as may seem desirable. The same precaution should be exercised as with tincture of iodine—namely, the skin, after being painted, is allowed to become dry before the operation is begun.

¹ ANNALS OF SURGERY, vol. xliii.

POST-OPERATIVE PAROTITIS *

By JOHN B. DEAVER, M.D.

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SECONDARY parotitis, occurring after operation, though not unknown to early surgery, has received attention only since the more general application of abdominal surgery has been practised. While not a very frequent phenomenon, it is an interesting one and worthy of more study than has been accorded it. The first reported cases all followed ovariectomy or some other operation on the female generative organs. Paget, however, as early as 1886, reported on 101 cases of secondary parotitis, one-half (51) of which took place after operation on the upper abdomen—gastrotomy, enterostomy, as well as after herniotomies, colostomy, abdominal and umbilical tumors, and penetrating injuries of the abdomen. The other 50 per cent. followed operations on the female generative organs. While at the present time, and in our experience also, secondary parotitis occurs more frequently after operations on the genitalia, especially in the female, the relative proportion has been considerably reduced. In fact, it is my belief that the type of operation, that is to say, the organ or organs operated upon, plays a minor rôle in the phenomenon of post-operative parotitis. Cases occurring in my experience may be reasonably attributed either to peculiarities of the pathology encountered, to local conditions, or to post-operative wound infection.

It is a well-known fact that the parotid gland is more susceptible to inflammation than the other large salivary glands. This is to some extent explained by the anatomical relation of the buccal orifices of the excretory ducts of the gland. According to some authorities there is also a physiological explanation for the ease with which the parotid gland is attacked by inflammatory processes, namely, the absence in the parotid secretion of mucin, the presence of which in the secretions of the other salivary glands acts as a bactericidal agent and a protection against infection. W. Stuart Low has shown in an interesting way the retarding influence of mucin on bacterial growth. He observed that sterile solutions containing mucin remained sterile for some time on exposure to air and that bacterial growth was inhibited when mucin was added to culture media. This interesting hypothesis, however, is not generally accepted, since not all bacteriologists are convinced of the bactericidal nature of mucin.

Post-operative parotitis may be classed into three groups: metastatic, occurring only in pyæmic conditions; ascending parotitis due to ascending infection *via* the excretory ducts; and traumatic, the result either of direct pressure on the parotid gland or the forcible manipulation of the jaw by the anæsthetist during operation. It is my impression that these factors are

* Read before the Philadelphia Academy of Surgery, December 12, 1918.

not infrequently the cause of subsequent parotitis. (We all know how, in some instances, during ether anæsthesia, there occurs difficulty in breathing, spasm of the muscles of the larynx, cyanosis, accumulation of mucus in the mouth, etc., and how in endeavoring to overcome this condition the anæsthetist carries the jaw forward by pressing against the angle of the jaw. Sometimes, indeed too often, this procedure is not carried out as gently as it should be. If it were possible to keep records of such faulty manipulation and how frequently it is followed by the development of trouble in the parotid gland, I venture to say my contention would receive considerable support. That trauma can take place in this way is readily understood in view of the anatomy of the region. The anterior of the two large processes of the inner surface of the gland passes into the back part of the glenoid fossa behind the articulation of the lower jaw, therefore it can readily be seen how injury to this process can occur. A more frequent traumatic factor, however, is that exerted through the fingers of the anæsthetist pressing on that part of the gland which extends downwards behind the angle of the jaw into the neck.

Infection may be carried to the gland by way of the lymphatics from diseases of neighboring structures, by way of the blood-stream, and by way of the excretory duct of the gland, Stenson's duct.

The latter route seems a very plausible one since it is well known that the mouth harbors numerous bacteria to the increased virulence of which, especially staphylococcus infection may be due.

The question of ascending infection has been carefully studied and from the microscopy of the same, as described by Bucknall,¹ we learn that the process is due to choking of the gland by débris containing micro-organisms which are the same as are obtained from cultures of the gland, its pus, the orifice of Stenson's duct and the oral cavity. While in view of the fact that to-day the asepsis of the mouth receives considerable attention before and after operation this theory may lose some of its practical value, the fact remains that infection can take place by this route.

It is interesting to note that in recent times the majority of the cases of secondary parotitis have occurred after severely infected conditions, appendicitis, peritonitis, perforating gastric ulcer, etc. In fact, next to ovarian cyst, perforating gastric ulcer is said to be the most frequent operative condition which is followed by secondary parotitis. This would be readily explained by increased absorption of the intestinal contents in such cases. In very plain language, I am inclined to say that the complication occurs most frequently from "dirty bellies" where infection has probably resided and been active for some time, and where, owing to incomplete or careless surgery secondary infection takes place. Why the latter sometimes chooses the parotid gland and so often does not, is not easily explained, except perhaps by the trauma, already referred to, or by individual disposition to affections of the gland in question. That such disposition exists is generally admitted.

¹ *Lancet*, 1905, ii, 1185.

And where it does exist the parotid gland would represent a site of minor resistance.

Sometimes the dryness of the mouth following anæsthesia is given as a contributing factor in post-operative parotitis. This might apply to the cases in which the complication occurs within a day or two of operation. But these are comparatively few, most of them taking place between the third and seventh post-operative days. On the other hand, the withdrawal of food by mouth and the resulting absence of oral secretions has also been assigned as a cause for the phenomenon. Indeed, a number of cases of parotitis are reported to occur during the starvation treatment in unoperated cases of (supposed) gastric ulcer. These cases might lend support to the theory of the bactericidal action of mucin. There seems little doubt, however, that interference with normal salivary secretion and with the protective action of the saliva as it drains down the ducts may be responsible for infection in such instances.

I am aware that I have merely touched upon various points in the consideration of this interesting phenomenon. I have done so in order to get opinions from the members of the association and with the hope that at some other time I may be able to give the question the study it deserves, or perhaps stimulate others to do so.

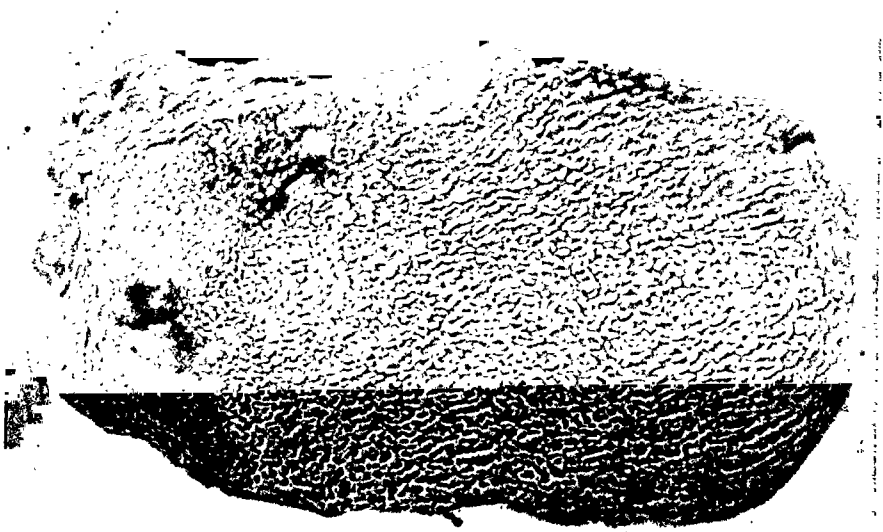


FIG. 1.—A typical "strawberry" gall-bladder.

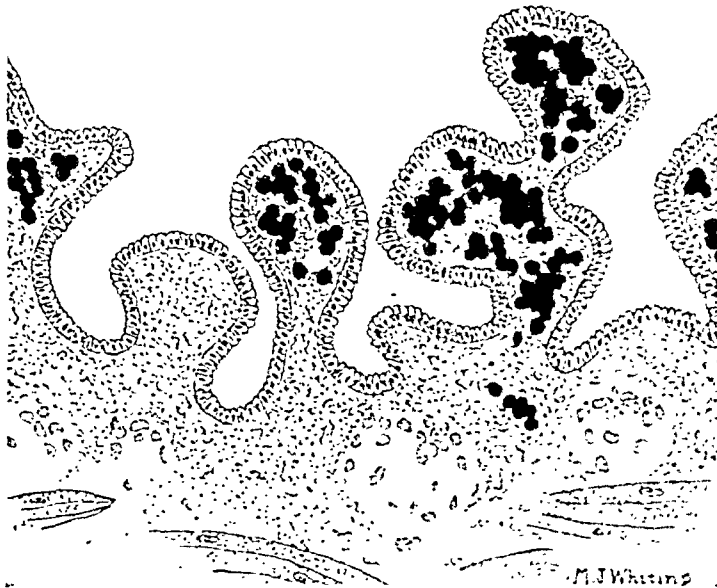


FIG. 2.—Microscopic section of a "strawberry" gall-bladder showing subepithelial cells filled with a lipid substance (stained with Sudan 3).



FIG. 3.—A section of an enlarged villus forming a papilloma which contains cells in the stroma similar to those in "strawberry" gall-bladders.



FIG. 4.—A gall-bladder showing normal mucosa, the "strawberry" condition and papillomas.

THE FREQUENCY OF "STRAWBERRY" GALL-BLADDERS *

BY WM. CARPENTER MACCARTY, M.D.
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AN apology is due the medical profession for the introduction of such a term as "strawberry" in characterizing a definite pathologic condition in the gall-bladder. It came into usage, however, as a convenient colloquial, descriptive term as a result of a lack of a scientific name for a pathologic condition which has been frequently found since surgeons have been removing diseased gall-bladders, symptoms of which experience has taught them cannot be relieved satisfactorily by simple cholecystostomy.

In 1910² the author studied a series of 365 gall-bladders which had been removed in the Mayo Clinic and presented the following grouping for the various stages of cholecystitis:

"*Group I: Cholecystitis Catarrhalis Acuta.*—In this group may be placed the gall-bladders which retain their general characteristics regarding size and color, both inside and outside; in other words, 'normal,' with the exception that the villi, congested and infiltrated with lymphocytes, are more prominent than normal. The infiltration may extend into the other layers of the wall. The condition occurs with or without stones. My attention was first drawn to this early condition by examination of a resected gall-bladder, which contained stones, but showed grossly no apparent change. Upon microscopic examination, however, the mucosa was infiltrated with lymphocytes and leucocytes. The diagnosis was sometimes made at operation by the thickened viscid bile, which seems to indicate hyperactivity of the glands of the mucosa and partial obstruction to the natural drainage. Other specimens in which no stones were found presented this same condition, and clinically gave a picture of cholecystitis. The stones which occurred in these cases were usually small, and may have been passed through the ducts in the cases in which none were found, or the condition may be the forerunner of stones. This early reaction of the mucosa was seen again in association with further changes, which constitute the second group.

"*Group II: Cholecystitis Catarrhalis Chronica.*—This condition varies from Group I only in degree, and one portion of the gall-bladder may belong to the first group and another portion to this group. The principal change grossly consists in an 'erosion' of the apices of the villi. These desquamated apices present themselves as yellow specks scattered over the mucosa. Otherwise the mucosa may appear normal or congested. This condition we have described as the 'strawberry' gall-bladder (Fig. 1) on account of the resemblance of the yellow specks to strawberry seeds. These have also been mistaken for fine stones. Microscopically, one sees that the epithelium

* Presented for publication January 29, 1919.

is lost and replaced by scar tissue. Clinically, there is nothing to distinguish this group from Group I. It is found with or without stones.

"*Group III: Cholecystitis Catarrhalis Papillomatosa.*—In this group there was only one specimen. One of the villi was enlarged and appeared as a papilloma. The condition was associated with stones and an acute catarrhal reaction in the mucosa. The papilloma was 2 mm. long and about 1 mm. in diameter. The cells of the epithelium covering the villi and papilloma were regular in size and shape and possessed nuclei showing no irregularities.

"*Group IV: Cholecystitis Papillomatosa Malignum.*—Like papillomata in other portions of the body, these often undergo an irregular or perverted hyperplasia, which manifests itself in marked reduplication of the rows of epithelial cells. Upon high-power examination of the epithelial cells the chromatin granules are irregularly distributed; the nuclei are irregular in shape and size. These cells may or may not dip below the basement membrane. Such cases have been found during exploration, at which time portions of the gall-bladder were taken for examination. This type does not occur in this series because the cases seen were studied at exploration of inoperable cases.

"*Group V: Cholecystitis Catarrhalis Carcinomatosa.*—The neoplastic condition in the least advanced portions of the changed mucosa appears as knob-like outgrowths covered by epithelium which is in a stage of malignant hyperplasia, which differs apparently from simple hyperplasia morphologically in that the cells are irregular, undifferentiated and show invasive growth. There are areas, however, which contain glands, the nuclei of which are regular and indistinguishable from normal or hyperplastic glands. The more extensive outgrowths arise from the mucosa and possess a base not unlike that seen in the papilloma. The body of the growth is composed of masses of epithelium which, upon high-power examination, presents extensive irregularities in the size, shape, and distribution of the chromatin granules. Differentiation between this group and Group IV, *Cholecystitis Papillomatosa Malignum*, must be made with reserve, because it is possible that the one is but a stage of the other. No specimens in my series presented sufficient evidence for grouping both conditions under one heading. They present papillomatous outgrowths, differing only in shape. Those under Group V were knobs, while those in Group IV were filiform and less massive. Earlier stages of carcinoma of the gall-bladder must be found and studied before the life history of such perversions of the epithelium can be accurately pictured.

"*Group VI: Cholecystitis Chronica.*—In this group is placed a condition, gradual stages of which may be seen in specimens of Group II. The continued desquamation of the apices of the villi is associated with proliferation of the connective tissue of the villi and submucosa. The surface, which is normally regular, contracts irregularly and leaves ridges of scar tissue. Upon microscopic examination the inner surface is seen to be void of epithelium and the mucosa has been replaced by scar tissue. The process is not always complete over the whole gall-bladder, as a result of which areas

of the condition described in Groups I and II may be seen. It may occur at operation with or without stones. It has been classified under the term 'cholecystitis chronica' because the mucosa has almost completely disappeared and the process is a chronic one involving the other coats of the wall.

"*Group VII: Cholecystitis Chronica Cystica.*—A stone may become lodged in the cystic duct or in the valves of the neck of the gall-bladder and cause obstruction and distention of the organ. This results in the thinning of the wall and destruction of the mucosa or flattening of the scar tissue ridges in the chronic cases. The stone is usually firmly embedded between the valves and cannot be moved in either direction. Microscopically the wall is a thin layer of connective tissue in which traces of the nuclei of muscle-cells may be seen sometimes. Such a gall-bladder attains great size, and is usually the type which presents itself as a large palpable tumor.

"*Group VIII: Cholecystitis Purulenta Necrotica.*—During any stage of inflammation obstruction to the cystic duct may be so great, or the pyogenetic infection so virulent, that disturbance of the circulation or multiple abscesses in the gall-bladder may occur. The specimens are usually distended, dark blue or black, the contents pus or blood and usually not bile-stained.

"*Pericholecystitis Acuta and Chronica* must be considered a sequel to any of the above-mentioned degrees of inflammation. Even in the earliest degree of cholecystitis catarrhalis acuta the process may extend to the serosa through the lymphatics, and it is not infrequent to see adhesions, usually to the omentum and transverse colon, in this stage."

Since this classification was made over 5000 gall-bladders have been studied. No marked change has been made but such conditions as "strawberry" and papillomatous gall-bladders have become common occurrences.

It may be seen that the strawberry appearance was described as being due to "erosions" of the apices of the villi of the mucosa. This is an error as I believe is also the case in Moynihan's³ description of the appearance as being due to minute deposits of stones. In his case the error was due probably to an insufficient number of cases for observation and a lack of detailed histological study of perfectly fresh specimens. In my own case it was undoubtedly due to the fact that I studied fixed specimens which had probably been extensively and perhaps harshly handled before they came into my hands. The epithelium was undoubtedly eroded in some advanced cases in the gradual pathologic process of erosion of the mucosa, but that the great majority of cases represent this condition is a mistake. The epithelium is intact and the appearance is due to the presence of a lipid substance within the swollen connective-tissue cells which lie just beneath the epithelium (Fig. 2).

The villi may or may not be much larger than normal, although in many cases the villi are several times the normal in size. The condition may be present in one, many, or all of the villi. The villi are occasionally so large and branched that they form papillomas (Fig. 3) which may be single or

multiple (Fig. 4). Histologically such papillomas are identical with the villi of the "strawberry" gall-bladder, being merely larger and branched.

In a series of 5000 gall-bladders removed between October 17, 1911, and September 11, 1918, there were 936 (18+ per cent.) "strawberry" gall-bladders and 198 (4 per cent.) papillomatous gall-bladders.

A most interesting and important fact is the increased and relative frequency with which this condition has been noted since cholecystectomy has become a more common operation.

TABLE BY YEARS

	Number gall-bladders	Strawberry gall-bladders
1912	230	17 (7.4 per cent.)
1913	527	83 (15.8 per cent.)
1914	821	144 (17.54 per cent.)
1915	899	204 (22.69 per cent.)
1916	900	201 (22.33 per cent.)
1917	927	178 (19.2 per cent.)

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THE FREQUENCY OF ADENOMYOMA OF THE UTERUS *

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SINCE the publication in 1903 and 1908 of the excellent and complete monographs on the subject of adenomyoma of the uterus by Dr. Thomas S. Cullen, but few articles have been contributed to the literature. In view of the fact that his report contained only 73 (5.7 per cent.) adenomyomas in 1283 myomas of the uterus, and since these figures have not been confirmed by an equally large series, it seems timely to add a report from the Mayo Clinic.

Nothing in so far as gross and microscopic description or the origin of this condition can be added to what has already been so well presented.

Between 1906 and 1918 (October 1st) 3388 fibromyomatous uteri were removed in the clinic. Two hundred and eleven (6.43 per cent.) of these contained adenomyomas. In 5 cases the tumor was in the fallopian tubes. The frequency is somewhat greater in this series than in that of Cullen, but the figures are so close that from 5 to 7 per cent. expresses it safely.

The last 109 cases of the series were studied with reference to certain clinical features which might be intimately associated with the condition. Ninety-five patients (86 per cent.) were married; 41 per cent. gave histories of having had miscarriages, 50 per cent. suffered from profuse and prolonged uterine bleeding, and 31 per cent. from irregular bleeding. The average age of puberty was 14.3 years. Sixty-five per cent. of the married women had borne living children. In 5.5 per cent. of the cases epithelioma of the cervix or carcinoma of the body of the uterus was associated, neither of which conditions bore any apparent relationship to the adenomyomas. In 72 per cent. other pathologic pelvic conditions were associated, such as ovarian cysts, chronic or acute salpingitis, uterine or cervical polypi, cystic cervicitis or prolapsus uteri. In no case without the association of a malignant condition was the clinical diagnosis one of malignancy. In no case was a positive clinical diagnosis of adenomyoma made previous to operation. The clinical diagnosis was clothed in such terms as fibromyoma or pelvic tumor, both of which diagnoses show recognition of definite pathologic conditions of a neoplastic nature without attempting to specify in terms of detailed pathology.

The condition as related to years is as follows:

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MACCARTY AND BLACKMAN

Year	Myomas	Adenomyomas	Adenomyomas in fallopian tube
1907	150	0	0
1908	154	6 (3.8 per cent.)	0
1909	198	6 (3 per cent.)	0
1910	213	8 (3.7 per cent.)	0
1911	228	18 (7.8 per cent.)	0
1912	231	12 (5.1 per cent.)	0
1913	274	21 (7.7 per cent.)	0
1914	316	22 (6.9 per cent.)	0
1915	348	23 (6.5 per cent.)	0
1916	386	37 (9.5 per cent.)	3
1917	378	36 (9.5 per cent.)	1
1918	301 (to Oct. 1)	22 (7.3 per cent.)	1
	<hr/> 3177	<hr/> 211 6.43 per cent.	<hr/> 5
	211		
Total,	<hr/> 3388		

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ABDOMINAL DRAINAGE *

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IN looking over the statistics of the Harper Hospital of Detroit for the year ending December, 1916, we noticed there were 4412 operations done that year by general surgeons and gynecologists.

Of this number there were 2652 abdominal sections. Of these 384, or 14 per cent., were done by gynecologists and 2268, or 85 per cent.+, done by the general surgeon.

This shows conclusively that the tables have completely changed in the past twenty years. If this is a fair average of the hospitals of the country, it is certainly true of our Ohio Valley General Hospital in Wheeling, then we are to believe that the general surgeon is now doing more abdominal work than all of his other work combined.

It is for this reason that the writer was stimulated to take up this vital subject of abdominal drainage.

Although the question is an old one, there are still conflicting opinions as to when the peritoneum can be trusted to independently push back an invading foe from the abdominal salient.

There are those who will not hesitate to impose a heavy tax on this delicate membrane, and even in the face of greatly diminished body resistance, let the abdominal cavity do its own scavenger work.

The whole question is more or less dependent on the judgment and experience of the individual surgeon. Perhaps, after all, there has been ample justification for the cry against the promiscuous use of the iodoform tamponade of Briddon, the drain of Mikulicz, and the taxidermic methods of past years. But whether this radical anti-drainage teaching, with its far-reaching influence, has yielded the best results, is open to discussion.

In the Mütter¹ lectures on Selected Topics in Surgical Pathology, Roswell Park, quoted by Charles K. Briddon,² says: "Among all the defensive powers of the system, the capacity of resorption is, perhaps, the most important protection enjoyed by the cells and tissues composing the organism. This power seems to be enjoyed in the highest degree by the peritoneum, which is known sometimes to tolerate and dispose of relatively large amounts of infectious material."

Time and experience have not in the least detracted from this statement, made nearly thirty years ago. Park or Briddon, masters of that day, did not wish to be understood as saying that "the natural protection against

* Read before the Section in Surgery at the Annual Session of the West Virginia State Medical Association, October, 1918.

invasion of cocci was a warrant for the omission of any of the precautions that experience has proved to be useful." Indeed, the influence and tendency has been quite in accord with this fundamental teaching. This great capacity of the peritoneum for resorption, and its power to put up a stiff defense, has led the present-day surgeon to drain less and less.

When to Drain.—The tendency to dispense with drainage following peritoneal infection has led Doctor Munro ³ to formulate three interesting factors to be considered:

"1. The individual equation as regards susceptibility to infection. This factor cannot be determined by any known reliable method of examination. Judgment that comes with experience counts for much in estimating its value.

"2. The virulence of the infection. The species and the presence of the organism may be quickly and quite accurately determined by coverslip examinations. But this does not differentiate the virulence of the individual case.

"3. The presence or absence of distinct foci of infection. This cannot always be determined with safety or accuracy at the time of the operation. Consequently, if there is a reasonable doubt as to one of these factors we believe that some form of drainage is conservative."

Posture in Abdominal Drainage.—Posture has become a very important adjunct in the treatment of peritoneal sepsis, and, in passing, it is with grateful appreciation that we pay tribute to the memory of the founder of Fowler's position. The basic principle was established, that the most active and rapid absorption into the lymphatics takes place from the diaphragmatic and omental peritoneum, while the pelvic peritoneum is very slow to absorb (Munro). The demonstration of this fact led to Fowler's observation and the position which bears his name.

Hill ⁴ makes use of various positions in his abdominal work, to facilitate drainage, according to the location of the area of involved peritoneum. He employs the Fowler position, the prone or ventral decubitus and the lateral position. Certainly the position of the patient is an important factor in the recovery of the more severe cases of abdominal infection.

We wish to urge the importance of transporting a patient in the sitting position where a peritoneal sepsis is suspected. The writer has insisted on the observance of this step in bringing these patients from a distance to the hospital. Doctor Munro ⁵ has emphasized this step several years ago, and spoke of the cardiac weakness in patients of this class as being dependent on heart changes secondary to general septic absorption. If this toxæmia is minimized, rather than increased by posture of the body, there is less to be feared as regards circulatory shock and collapse.

War Wounds of the Abdomen ⁶.—Regarding the drainage of war wounds of the abdomen, Sir Anthony Bowlby in his splendid paper, "The Development of British Surgery at the Front," just published under the supervision of the British Medical Association, says: "Abdominal drainage is most probably of little use except in local lesions." In speaking of the statistics in the present campaign, he reports an operative mortality of 50 per cent., and

while such a report would be considered an awful death-rate in civil practice, it was considered good under existing conditions. As a consequence of the first shock of war falling on a peace-loving and unprepared people, and waged in mudholes, polluted with the manure of centuries, before the crusade against the murderous Hun was six months on the way, there began to be seen in the hospitals of France and England infections of a kind and severity unknown to surgeons trained in the Listerian era. But how very different are the present-day military and civilian problems in wound treatment.

Dr. C. L. Gibson⁷ has said: "The treatment of war wounds is a highly specialized branch of surgery, and the rules of civil practice apply hardly, if at all, at the front." The seriously injured factory hand will come, as a rule, from clean surroundings, he has been properly fed and clothed, he has not been unduly exposed to cold and wet, and his body well rested when his injury is sustained. "The wounded soldier will probably have been subjected to harassing conditions of warfare. His injuries may be multiple. It may be some time before he is picked up and in addition to the other conditions he may be deprived of food and drink for a long period of time. The journey out of the trenches is long, tedious and hazardous, and may greatly add to the patient's shock. It is, therefore, obvious that special training for proper treatment of such cases must be obtained and must be derived from practical experience at the front and cannot be replaced by theory."

The Carrel System.—The new faith, as taught by Carrel, whose weapon for wound disinfection has shown more weight than any other arm in offensive action, has led to the rewriting of some chapters on this subject of wound drainage. We know, for instance, that the sterilization of septic pockets is quite easily accomplished by the omission of the counter opening in the dependent part of the wound, and by following the Carrel ritual, which is familiar to you all and may be defined as: A combination of procedures, with surgical operation and mechanical cleansing, by which a chemical substance is used under specific conditions of contact, concentration, time and under bacteriological control. We have repeatedly demonstrated that in some of these intra-abdominal, rotten abscess cavities, whether of appendix or tubal origin, one can see the charted microbic curve progressively fall to the zero line, when the instillation tubes have been carefully placed and the technic of Carrel rigidly enforced. It should be emphasized right here that Carrel never intended his system of wound sterilization to take the place of early clean surgery or exteriorization of wounds, as Captain Wooler calls it, and the removal of all foreign material. Doctor Gibson has well said that while chemical sterilization has become a most valuable adjuvant, it must not be regarded a substitute for good surgery.

Gunshot Wounds of Abdomen.—The subjoined report from a well-directed ambulance somewhere in France⁸ is interesting to us in this dis-

cussion, as both operators discourage the use of drainage in gunshot wounds of the abdomen. Of 64 abdominal wounds, mostly multiple, received in the reporter's ambulance, 22 died in a state of shock within a few hours, without operation; 20 others treated expectantly on account of the benign nature of the injuries recovered. Forty cases received operation with 20 recoveries and 20 deaths. It was claimed that the season of the year seemed to have a particular effect, as there was a mortality of 60 per cent. in the cold season, as compared with 40 per cent. in the warm season. Fifteen of the 40 cases had a single abdominal wound, 25 had at least two, and the others varied from 4 to 20 wounds. Multiple wounds gave a mortality of 68 per cent. as against 20 per cent. for single wounds. Operation was performed whenever the pulse was perceptible. The writers have entirely discontinued lavage of the peritoneum with ether, owing to the abrupt fall in pressure. Warm salt solution was used. Drainage of the abdomen was not encouraged as the authors claimed it was useless or even harmful, but occasionally the Douglas pouch was drained for from 24 to 48 hours.

Abuse of Drainage Tube.—Hathaway¹⁰ condemns the drainage tube, and although his results are brilliant, his position will hardly be subscribed to without reservation by the members of this Section. He believes that if surgeons will take their courage in both hands and will not be frightened by a little infection, leaving it to be dealt with by the natural resistance of the tissues to infection, and will give up the use of drainage tubes, they will not only find their results very much better, but will find their outlook on surgery totally changed. All that is necessary is to put something into the tissues which will keep a "passage" open, but which does not leave an open "drain." If a passage is required to be kept open, Hathaway puts in a piece of soft folded rubber, for instance, in an appendix abscess. This allows pus to come away, but will not leave an open "drain" by which secondary infection of staphylococci, from the skin, or other organisms can gain entrance.

War surgery has taught what should be the two main principles of civil surgery: (1) Early and complete operation. (2) That secondary or mixed infection is worse than primary infection. While the tissues of the body can, if given a fair chance, deal with one infection only, if that infection becomes a mixed one by entrance of organisms from outside, then the last state is worse than the first. Applying his experience of modern war surgery Hathaway started sewing up ordinary staphylococcic abscesses of the subcutaneous tissues, after incision and wiping out with bipp, and found they healed by first intention.

Hathaway then went a step further. He saw a case of perforated gastric ulcer two hours after perforation, and operated within four hours. He sewed up the perforation, and, as it was near the pylorus and tended to close it, did a gastro-enterostomy. He mechanically cleansed the peritoneum of food, washed out with flavine, and sutured completely. The result was healing by first intention and an uninterrupted recovery, better than he had

experienced with the use of a drainage tube. Then he had to treat a bad compound fracture of tibia and fibula with a large external and contused wound, in a boy who had been run over by a motor lorry. He excised well clear of all damaged tissues, wiped out with bipp, and so mechanically cleansed and closed the whole wound by primary suture. The result was healing by first intention without a trace of suppuration.

The next step forward was in a case of gonococcal peritonitis. The peritoneum was infected and the abdominal cavity contained a turbid fluid; he removed one fallopian tube full of thick gonococcal pus, cleansed the peritoneum mechanically, washed out with flavine, and closed without drainage. The result was uninterrupted recovery and healing by first intention.

We quote freely from the report of Hathaway's series of cases on the abuse of the drainage tube, hoping it will provoke the fullest discussion.

I believe it is yet to be proved that the closing of a septic abdomen without drainage is an unqualifiedly rational procedure. No matter how thoroughly a peritoneal toilet may be made, there often lurk behind myriads of colonies of pathologic organisms, which may overwhelm the resistance, paralyze the arm of defense, and change what has seemed, at the operating table, a victory, into defeat.

Drainage Following the Pus Appendix.—Dr. John W. Keefe¹¹ in his excellent paper on Abdominal Drainage has asked the question: "Where shall we make our incision for removal of the appendix?" The right rectus incision undoubtedly offers a better abdominal exploration in cases of chronic appendicitis; however, the possibility of a post-operative hernia must be considered where drainage becomes necessary. It should be remembered that this incision presents other disadvantages, in that it is not always directly over the offending organ, and, as Doctor Kelly has pointed out, drainage thus may become difficult. After all, many things must influence the choice of incision, the location of the pain, and some definite conception of the pathology, based on the clinical picture, and the laboratory findings. The subject of drainage in a case of appendicitis can not be definitely decided until the abdomen is opened. In acute appendicitis when the question of drainage is always to be considered, the writer has almost invariably preferred the McBurney "gridiron" incision; recognizing with Doctor Keefe that it is least likely to be followed by a hernia, and through this incision adequate drainage can be obtained. We have never had the least trouble by sufficiently enlarging the incision, in exploring the pelvic basin, where this step seemed necessary. Again, should it be necessary to interrogate the gall-bladder or stomach, or to deal with these organs surgically, I am convinced that a second incision is the wiser course to pursue.

While we cannot subscribe to all that has been written by Dr. J. W. Long,¹² of North Carolina, it is interesting to record his experience in a series of 39 cases of acute appendicitis, some of them of the gangrenous type. He closed the abdomen in each of them, and his results were gratifying in 37 of the series.

ABDOMINAL DRAINAGE

Dr. Howard A. Kelly¹³ writes: "An appendiceal abscess should never be disinfected and closed without drainage. When there has been much pus, a large opening ought to be left for free drainage; but before the drain is inserted the relations of the abscess must be studied, and pressure made upon it in various directions in order to ascertain that there is not some other cavity communicating with the primary one."

Most of us have followed the teaching of Dr. John B. Deaver, where the cul-de-sac is suspected of harboring pus, by introducing a catheter and aspirating with a syringe, during and after the operation.

Doctor Kelly definitely lays down essential points to be remembered:

"The drain is only a drain to a limited extent and for a short time; it acts chiefly as a protective pack.

"It is essential that the whole septic area should be drained.

"The drain must be loose in order that it may absorb rapidly. It must never be firmly packed.

"The drain must have exit through a large orifice.

"Whenever possible, the drain must be to an orifice in a dependent position. The drain must be watched, and as soon as it ceases to discharge it must be loosened or wholly withdrawn.

"In a small abscess it is sometimes best to leave the drain in for a week. Fatal infection has occurred from removing it too soon and thus breaking up protective adhesions."

Although Doctor Kelly's words were written thirteen years ago, I am convinced that this teaching may be safely followed to-day. Where there has been a general peritoneal infection, or in cases requiring temporary drainage, we have frequently seen the happiest results from a suprapubic or loin stab-wound drainage. Yet Deaver¹⁴ reports two cases of obstruction of the bowel following adhesions along the tract of the pelvic drainage, and declares that in the future he will omit the pelvic drainage in cases with but little inodorous fluid. Hitzrot, of New York, reported to the writer personally, three other such cases in his service at the New York Hospital.

We prefer the split rubber tube, wrapped with gauze and covered with rubber dam, or the rubber dam and gauze wrapped or rolled cigarette fashion, judiciously placed at the bottom of the septic pit, or flanking definitely the seat of infection. When the drainage passes only to the fascia we have used the ordinary rubber band. The writer is indebted to Dr. Frank S. Mathews, of New York, for this simple yet efficient means of draining small pockets.

Whatever material is used, we should always remember the fact pointed out by Coffey and emphasized by Keefe, that a drain is efficacious only in proportion to the area of a transverse section at the point of obstruction. A point we wish to emphasize here is the imperative importance of the surgeon, or a skilled and trustworthy assistant, following up the mechanism of all abdominal drains. The writer, more than once, has seen a tragedy due

to a cigarette drain blocking the passage of septic material, with the inevitable retention, overwhelming toxæmia and death.

Remember, in using the drainage tube as the central core of the cigarette, or as an individual drain, care must be exercised in the selection of a perfectly pliable yet non-collapsible pure rubber. We have known of perforation of the intestine, due to pressure of an unyielding white hose pipe tube of the fishtail cut.

Many of us who served our internship in the early nineties can bear testimony to the faithful performance of the large glass tube, aspirating syringe and soft catheter in the pus abdomen.¹⁶ The writer published several years ago a series of seven gunshot and stab wounds of the abdomen, each with visceral perforation; the glass tube was used in each of these cases with recovery, without hernia or secondary infection. Notwithstanding the large glass tube has been relegated to the junk of seldom used armamentaria, we think that there is still a place for it in selected cases.

Rutherford Morrison¹⁶ regards the toughened glass tube of Keith the best form of drainage in pelvic sepsis.

Howard A. Kelly¹⁷ says the drainage ought never to be omitted in the pelvic abscess and is best carried out by means of rubber tubes a centimetre in diameter.

It was the writer's privilege, many years ago as an interne in Presbyterian Hospital, New York, to assist in the operation and have the after care of a case of Dr. Charles K. Briddon's:¹⁸ A neglected pyosalpinx, with firm old adhesions. In the course of extirpation there was a complete transverse rupture of the rectum, necessitating the formation of a temporary artificial anus. A secondary operation was performed for reconstruction of the rectum, from which the patient recovered with complete control of function.

In this classical case, as in all of the graver forms of pelvic suppuration, Doctor Briddon used the intraperitoneal iodoform tampon. To facilitate the removal of the gauze, it was the custom of this operator to pass one or more glass tubes down to the bottom of the cavity and to pack loosely around these a liberal amount of gauze.

With regard to these graver forms of pyosalpinx we will all accept without reserve the teaching of that great English gynæcologist, Lawson Tait. Whether we drain or not, certainly his words ring as true to-day as they did thirty years ago. In an address delivered to the French Surgical Congress in 1891, Tait said:

"I am quite certain now that in the hands of a competent operator there are no adhesions of the uterine appendages which cannot be overcome, and no case ought to be left unfinished. Incomplete operations are the opprobrium of abdominal surgery, and operators ought to be more discredited by them than by anything else."

Dr. J. Y. Brown,¹⁹ of St. Louis, in a recent essay remarkable for its philosophic grasp, is of the opinion that the outcome of these pus tube cases

depends largely on the proper application of the drain. After the enucleation which is usually extensive, the cul-de-sac is left denuded.

Joseph Price long ago emphasized the value of the coffer dam, and Coffey, of Oregon, later elaborated on the technic of applying this drain. After the removal of the diseased tubes and the completion of the pelvic toilet, with the patient in the Trendelenberg position, the intestines are lifted from the cul-de-sac. Gauze tape about 36 inches in length is now placed from right to left, filling the cul-de-sac and covering all raw areas. The end of the gauze is then brought out at the lower angle of the wound and slipped through a very thin rubber tube. Brown is confident that this type of drain will prevent post-operative ileus. He pays a generous and well-deserved tribute to the genius of the late Joseph Price when he says: "To him more than to any one man in America, is due the credit of having placed pelvic surgery on a sound and substantial basis."

Drainage in Tuberculous Peritonitis.—We have been definitely taught, and the teaching has been strengthened by experience, that the peritoneal cavity, when the seat of an unmixed tuberculous infection, should never be drained. The explanation has been found in an etiologic factor, which has been clearly explained by Dr. W. J. Mayo,²⁰ who has called tuberculous peritonitis a symptom and not a primary disease, arising secondarily to a local lesion, usually in the fallopian tubes or the intestinal tract, or from retro-peritoneal glands. The abdominal ostia of the fallopian tubes in tuberculosis are usually open, while in gonorrhœa, Murphy has taught, they are nearly always closed. The infective tuberculous material from the tubes passes with freedom into the peritoneal cavity, and, as pointed out by Doctor Mayo, the resulting reaction with accumulation of ascitic fluid we speak of as tuberculous peritonitis. The real explanation of the exceptional recoveries of these patients following abdominal section is, that the fimbriated mouths are closed by adhesions, or by becoming attached to some neighboring part of the peritoneum. But the tragedy comes too often following incision and drainage; the mixed infection, the fecal fistula, the hectic with its "picket fence temperature," and the fatal exhaustion. Doctor Mayo therefore concludes:

"1. Those afflicted with tuberculosis do not die of the disease, but from the associated sepsis. 2. Drainage of the abdomen should never be used in tuberculosis of the peritoneum. 3. Pure products of tuberculosis in the pelvis should be removed, wherever possible, by clean, careful operation."

The writer has only attempted to touch the fringe of some of the important phases of this drainage problem.

We do not wish to be understood as making a plea for any particular form of drainage in a purulent peritonitis, but humbly present a simple chronicle of facts, opinions and observations from the hospital wards.

This whole subject of drainage presents certain definite scientific principles which must be applied with judgment to each individual case. Doctor Draper at one time said, "Mere technic is easy, the modern surgeon must

be more than a mere craftsman." Get hold of the principles, therefore, and do not follow with dogmatic blindness an unvarying ritual in every pus abdomen which you may lead to the operating table.

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FRACTURES OF THE UPPER END OF THE HUMERUS

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THE treatment of fractures of the upper end of the humerus which involve the shoulder joint have been various, but the results have been, in the great majority of cases, remarkably alike; that is, unsatisfactory both to the patient and to the surgeon; long periods of disability with restriction of motion—many of them presenting a permanent disability out of all proportion to the apparent pathology.

Forward and backward motions at the joint have been usually recovered in greater part, but the restriction to motion following fracture of this type is usually apparent in abduction movements, especially after the arm has swung above the horizontal plane, and external rotation is restricted and has been recovered only after long periods of time or not at all. Many of the patients who have suffered from this type of fracture have to a certain extent only themselves to blame, as they lay down very early on account of the pain produced by passive and active motion at the shoulder joint, and once they are able to get the hand to the head they become reconciled to the result and never make the extra effort necessary to the full recovery of abduction and rotation movements at the joint. These fractures have been treated up to the present time with remarkably little intelligence and apparently with remarkably little understanding of the physiological anatomy of the shoulder joint and an equally slight understanding of the pathologically mechanical factors which have entered into the problem of restoration of function once there is a solution of continuity of the bony structure with injury to the joint surfaces.

These cases are immediately (in the great majority) locked up with a shoulder cap, oftentimes the entire arm and forearm swathed in bandages; the forearm carried across the chest and slung from the neck with a sling, this position perforce putting the lower end of the fracture if not impacted into internal rotation—if impacted, putting the whole length of the humerus into internal rotation. If the shaft of the humerus is also involved coaptation splints are added, and oftentimes a right-angle splint at the elbow is included. These are left on for a variable length of time, but it has been my experience that it is more often four or five weeks than less, and I have seen some cases where splints have been left on for a longer period of time, before motion was instituted. Under this treatment it is a long series of months before a workable arm is obtained, and the wonder is not that it is so long a time before recovery of a useful arm, but that they recover the use of the arm at all.

Nearly all of these cases for months and even years afterward, and in fact for the remainder of their lives, show certain pretty definite restriction of motion, especially in abduction and external rotation. They gain the motion

which they have at the expense of a tremendous amount of pain when motion is begun and for a long time afterward, in which subdeltoid bursitis many times plays a part and brachial neuritis is a close second, but of which the major part is played, in our opinion, by certain definite inflammatory roughening of the joint surfaces themselves—traumatic arthritis.

The second type of treatment, which shows more intelligence than the preceding because based upon a certain amount of definite anatomical knowledge, has been used principally in those cases where the head of the bone has been split off and abducted, leaving the shaft so clearly out of continuity that it was obviously impossible to bring the two surfaces together in the ordinary position of treatment, and here the arm with the lower end of the fragment (the shaft) has been abducted and manipulated with the hope of entangling the broken-off head and so bringing it down into a reasonable alignment with the shaft, or of treating it in this position of abduction after the two surfaces have been coapted as nearly as seemed possible. Lately, in a few cases, we have had reports of abduction with extension, a logical method, but this in the main has been used in those cases of military fracture that have resulted from the present war.

In all these cases the period of time of treatment has been much the same, but I think that on the whole the results have shown some change for the better. Some few later-day writers have advanced the idea of treatment in abduction and external rotation, but in every case where I have studied their charts, illustrations or photographs, their treatment has shown internal rotation and not external rotation—most of these cases being treated on ambulant splints, the arm in abduction, the forearm on the horizontal plane in front of the transverse plane of the body, which means internal rotation of the humerus always. So far as I have seen there is no ambulant splint of any type which permits abduction and at the same time external rotation without being absolutely or practically impossible of application. A patient does not wish to go about with his arm in the air like the Statue of Liberty.

Fracture of the upper end of the humerus is an extremely common kind of fracture, and is usually the result of a fall by middle-aged or elderly people with the arm in abduction and internal rotation. There are several types of these fractures, and it is necessary to their understanding that one should have a clear conception of the anatomy of the shoulder joint.

The joint itself, consisting of the shallow cup of the glenoid and the head of the humerus, together with its capsule, is a loosely fitting joint, the head of the humerus being held into the glenoid socket by the various muscles which surround it, and not by the capsule. The supraspinatus above, the infraspinatus and teres minor posteriorly, and anteriorly the subscapularis, by their insertions into the greater and lesser tuberosities serve to hold the head of the humerus against the glenoid. At practically right angles to these the tendon of the long head of the triceps behind and the biceps and coracobrachialis in front cross the capsule and strengthen it. Over all is the very strong deltoid muscle. The inferior surface of the capsule is probably the

FRACTURES OF THE UPPER END OF THE HUMERUS

only part of the true capsule which is tense at any time, and this is true only in abduction. The head of the humerus may be for all practical purposes considered as a ball surrounded by muscles whose purpose it is to rotate it outward and inward and the supraspinatus above to tilt it upward so that the mean line of the deltoid (the deltoid pull) may become efficient in abducting the arm which it cannot do while the arm is against the side. (See Figs. 1 and 2.)

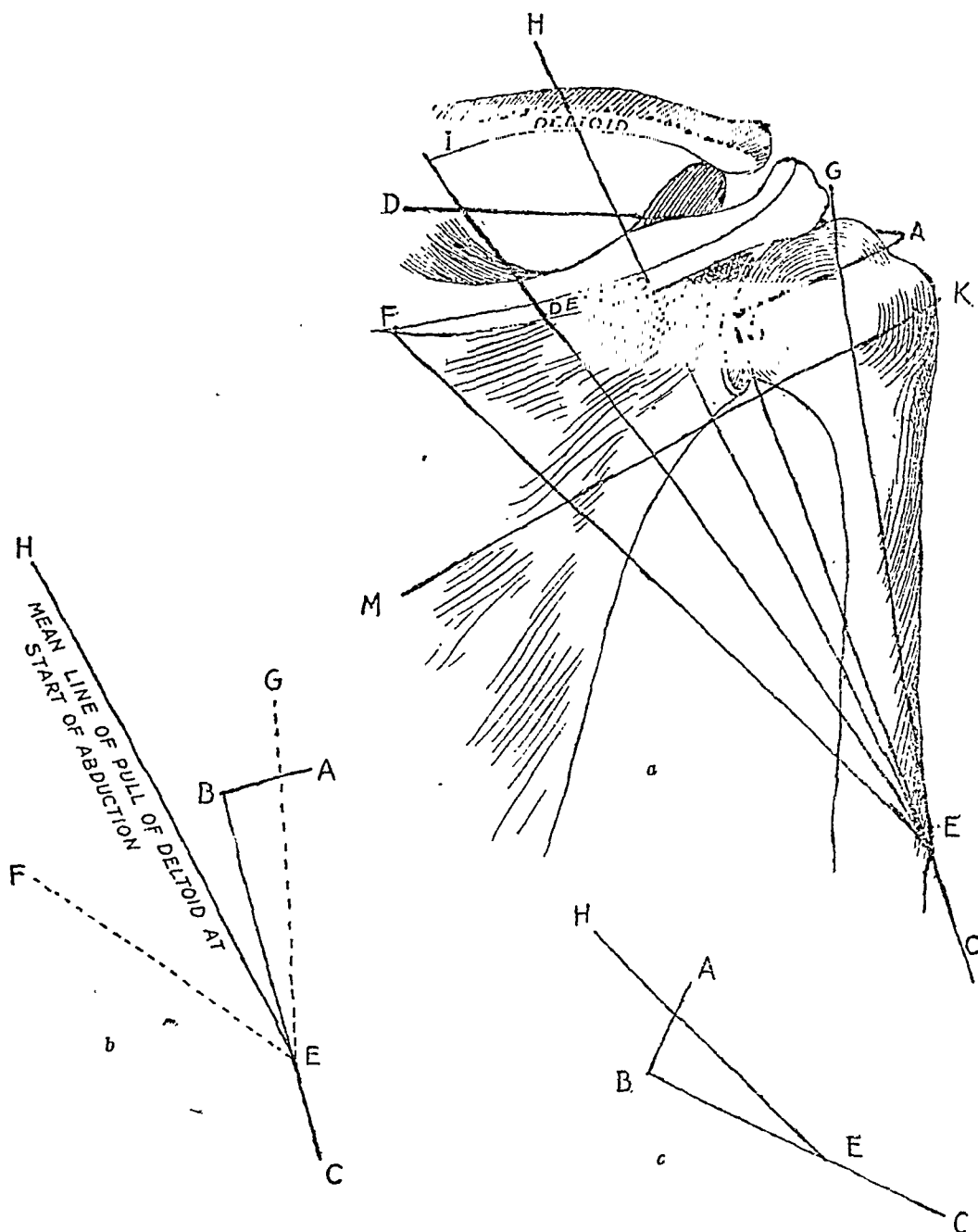


FIG. 1.—Showing the lines of pull of the fibres of the deltoid providing these fibres acted together, HE being approximately the line of such pull, showing that in this case it could not act on the lever ABC to abduct it. Assuming that the acromion portion of the deltoid acted as a separate muscle or as a separate contraction, then it could (consider the line GE and its effect acting at E on the long arm of the lever ABC) aid in starting the humerus upward in abduction, but should its fibres act simultaneously the line of pull would be inside the fulcrum B (a) and provided it was in contraction it would act in opposition to the line of pull to the supraspinatus, DA . In order to act on the long arm of the lever the line HE must fall outside the point B (fulcrum), and this is possible only after the long arm of the lever (the humerus) has been partially abducted (b), which is done up to this point by the supraspinatus DA acting at A on the short arm of the lever ABC . A , the power, B , the fulcrum, and C , the weight of the arm to be abducted. KM shows the line of pull of the short rotators causing external rotation. Especially pronounced, once there is a fracture of the surgical neck, putting out of commission the opposition of the pectoralis major and latissimus dorsi and teres major muscles.

The deltoid has nothing to do with abduction until after the supraspinatus has carried the humerus outward to a point sufficiently great so that the deltoid can come into play. What happens when these patients fall with the arm in abduction and how do we account for such a large number of fractures of this type? It is easy to say direct violence or excessive muscular action, but it is a pretty weak solution. Watch the normal abduction of the arm, standing behind the model.

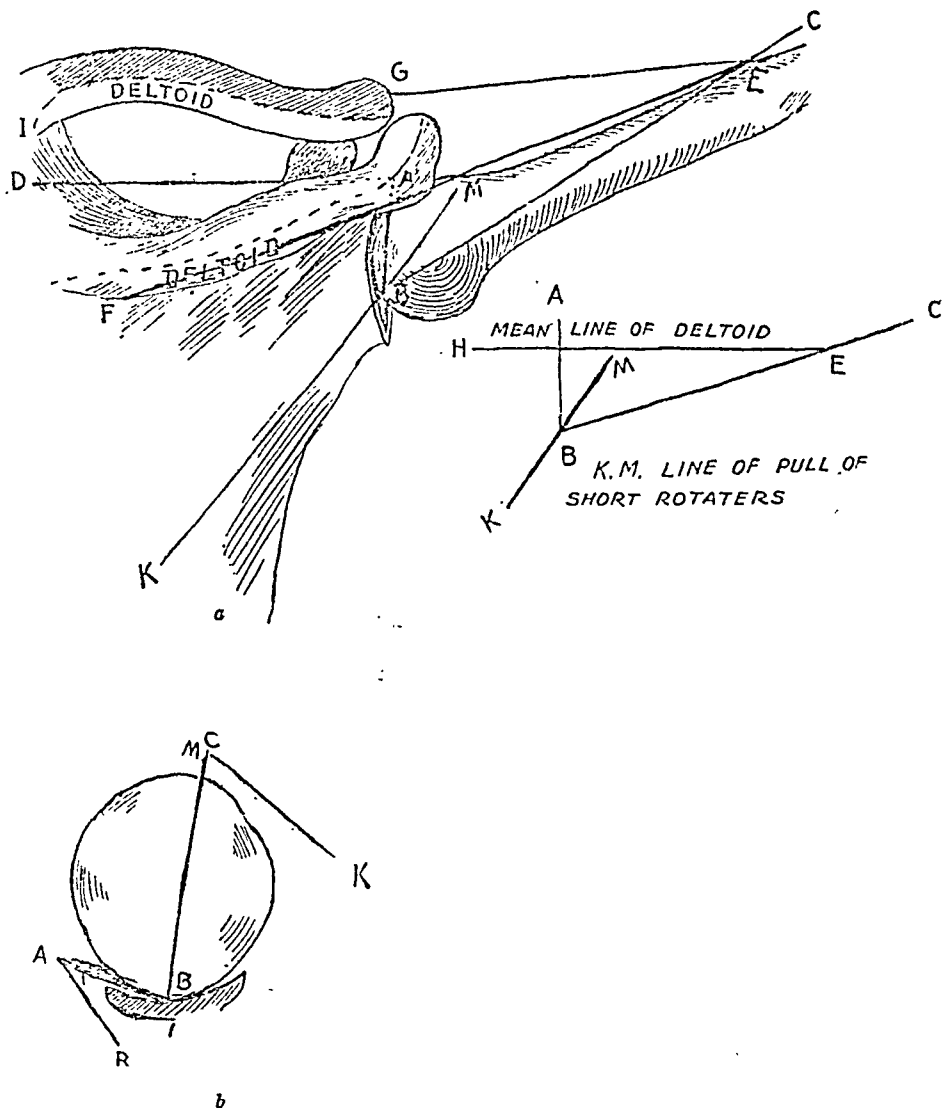


FIG. 2.—Mechanics of the second stage of normal abductions and of external rotation. This shows the lines of pull of the deltoid when the arm is partially abducted, GE , FE and IE . The line of pull of the supraspinatus, DA , acting on the short arm of the lever ABC , while the deltoid acts on the long arm of the same lever, its power being applied to E , a point between the weight C and the fulcrum B . Note also applied the fulcrum of the lever would be unstable and render worthless any amount of power applied. That force (KM), the line of pull of the infraspinatus and teres minor behind and of the subscapularis in front, is supplied by these three short rotators, without which the head of the humerus would slip upward, answering the pull of the supraspinatus and deltoid. Note that the line of pull of the short rotators passes through the fulcrum B ; therefore it acts merely as a tractor and exerts no force either on the long or short arm of the lever, consequently offering no impediment to the abduction, while at the same time rendering such action possible by keeping the fulcrum firmly in place. When the head is broken, KM and DA of Figs. 1 and 2 show how the upper fragment would be abducted and rotated outward. An entirely different leverage is formed, and the insertion of the infraspinatus and teres minor being on the long arm of this new lever would outweigh any pull of the subscapularis which could act on the short arm to oppose it and therefore the head of the bone would rotate outward (b). (a , DA , the pull of the supraspinatus) acting normally would simply tend to abduct the upper fragment.

FRACTURES OF THE UPPER END OF THE HUMERUS

With the arm extended fully and the hand in pronation (which means that the humerus is in internal rotation—not to its full limit but to a good degree in internal rotation) when the arm reaches a certain point in abduction, varying in different persons but always well above the horizontal plane, no further abduction of the arm is possible in this position; but if the humerus is now rotated outward from its position of internal rotation into external rotation, the arm (humerus) is freed immediately from its previous restriction and can be further abducted so as to approximate the arm to the side of the head. This movement is readily understood from a study of the normal anatomy of the humerus and the acromion process of the scapula. The greater tuberosity of the humerus in the position of internal rotation impinges on the tip of the acromion process of the scapula, between which and the greater tuberosity there is very little clearance even up to this point, and at this point the greater tuberosity is brought against the tip of the acromion, motion is arrested and cannot be carried in abduction beyond this point (Fig. 2). The actions of the short rotators now come into play; the humerus is rotated outward by the infraspinatus and teres minor, which brings the normal depression that exists in the head of the humerus between the greater tuberosity and the lesser tuberosity into line with the tip of the acromion process and this movement permits exactly enough clearance between the bones so that the humerus is permitted to continue the arc of abduction.

Should a patient fall with his arm in abduction and external rotation, nothing would happen to him save that his arm would be forcibly extended above his head, the arm resting alongside his head, and one could not imagine a force other than a sharp edge which would produce a fracture at the neck of the humerus. But one never falls that way; instinctively he throws out his arm in abduction, his hand in pronation, and as the hand strikes the floor first a terrific impetus (the impetus imparted by the entire weight of the victim) is given to the abducting arm. The greater tuberosity goes smash up against the tip of the acromion process (see Fig. 2), which is a strong bony structure constructed exactly like the arch of a bridge. One of three things happens where fracture occurs: either the tip of the acromion must break, which it seldom does, or the tuberosity of the humerus is smashed off together with the insertions of the supraspinatus, the infraspinatus and teres minor; or the tuberosity resisting the strain holds and the entire weight of the man's body falls upon the neck of the humerus and this gives way. If all three hold then a dislocation is all that results and this is common in youth. In older persons the bony structure is changed and fracture is the rule.

It is surprising how often the greater tuberosity alone gives way, thus distributing the pressure and saving the neck of the humerus, the fracture resulting simply in a split-off greater tuberosity (Figs. 3 and 4). If the force is sufficient and the break free, the short rotators, the infraspinatus and teres minor, aided by the supraspinatus to a lesser extent, may

pull the broken tuberosity entirely out of place, or it is pried out of place by the tip of the acromion process and it may even disappear behind the head of the humerus (see Fig. 4). More often, however, it is not entirely displaced. In many of this type the fracture of the greater tuberosity is minor in character and not sufficient in extent to free the head of the bone, the force continues along the intact shaft, the tip of the acromion acts still as a prying force to externally rotate the bone, and this force continuing dislocates the humerus through the only part of the capsule unprotected by muscles—the inferior portion, and a subcoracoid dislocation is added to the first trauma.

In the second variety the surgical neck of the bone parts, the head and neck oftentimes being tipped upward, abducted by the action of the supraspinatus and always rotated outward by the action of the infraspinatus and teres minor acting from behind aided by the prying force of the tip of acromion. Sometimes when the head of the bone is not rotated and abducted impaction follows as the last stage of the trauma. All these cases present the common complication of torn ligamentous structure, traumatized tendons and a joint also traumatized and usually filled with blood and effusion, and in those cases where the bony lesion is slight and deformity little or none this is the really important pathological condition which must be considered in the treatment of these cases of fracture of the upper end of the humerus.

Should displacement be associated as it is many times, then measures must be taken first to reduce the displacement, and once this is accomplished the mechanical problem is exactly the same as in those cases which clinically and by means of the X-ray have presented little or no deformity, *i.e.*, treatment of the injury to the joint itself rather than treatment of the broken bony structure.

The break itself, whether it be of the greater tuberosity of the surgical neck or whether or not complicated by an oblique fracture of the shaft of the bone in addition to the break above, presents identically the same problems, and the results are good or bad according as one recognizes that it is not the fracture alone which must be treated but a traumatized joint structure, and that the disability resulting from improperly locking up a traumatized joint for long periods of time is just as great in those cases showing by the X-ray a splitting off of the greater tuberosity without displacement as it is in the apparently much more serious type with fracture across the neck of the bone with or without displacement or impaction. Better results will be obtained if treated along anatomical lines where there is no impaction, but I have come to believe that in comparatively few cases is there real impaction in these cases of shoulder fracture.

If it takes place before the split-off head rotates externally, it is a matter of small importance; if it takes place after the head has rotated externally and is not broken up, then external rotation afterward will always be lost to a certain degree; but fortunately it takes place, if at all, before rotation of the head, and where rotation of the head can be demonstrated it is pretty

safe to conclude that there is no impaction. In these cases it is necessary to take into consideration the insertion of some of the other muscles.

The pectoralis major is inserted into the outer lip of the bicipital groove of the humerus and the latissimus dorsi and teres major are inserted into the inner lip of the bicipital groove. They are all below the site of the usual fracture of the neck and where there is no impaction they tend to pull the lower fragment inward and also rotate it inward as well.

The long head of the triceps behind and the tendons of the biceps and coracobrachialis in front tend to pull up the lower fragment, so that we have an upper fragment, the head of the humerus, broken off and if displaced tilted upward and externally rotated, a lower fragment pulled inward and always if not impacted rotated inward. Every case of fracture of this kind should have a stereoscopic X-ray taken if you wish to demonstrate the external rotation. The demonstration of rotation in any long bone from the ordinary X-ray plate is an impossibility and an absurdity.

The case represented by Fig. 7, a fracture of the surgical neck complicated by an oblique fracture of the shaft of the bone, demonstrated this external rotation beautifully when pictured stereoscopically. Although the lower fracture runs obliquely low down on the shaft of the bone, the line of fracture anteriorly passed internal to the insertion of the latissimus dorsi and pectoralis major, and this fragment, which is really in this case a third fragment of bone, moved with the upper fragment or head and showed the same external rotation which is shown by a fracture across the neck alone. The upper fragment, and in this case also the inner fragment since these two were more or less entangled and moved as one, demonstrated the external rotation produced by the infraspinatus and teres minor; while the lower fragment which is in this case also the outer fragment (a rather unusual condition) is internally rotated by the action of the latissimus dorsi, teres major and pectoralis major. /

The shaft of the bone entangled with the upper fragment or head (in this case the internal fragment) is also pulled slightly forward because the coracobrachialis is intact and is attached to this fragment. That it does not distort it more pronouncedly is probably due to the attachment of some of the upper fibres of the internal head of the triceps which serve to prevent further displacement. This is the type of case where damage to the musculospiral is much to be feared. It is not absolutely necessary to have a stereoscopic plate made of all of these fracture cases, because it is safe to assume that this rotation externally is exactly what has happened in every case.

Should we bring these bony structures together by manipulation in this position, the upper externally rotated and the lower internally rotated, we should hardly expect a good result, because external rotation would be lost while internal rotation would be increased. This is exactly what happens in these cases treated by the usual method, which, no matter what type of dressing is used, treats them in internal rotation. The abduction ambulant splints are no better from the standpoint of overcoming this external rotation,

because all that I have seen treat the arm in abduction to be sure which is an advantage—but they all place the forearm forward of the side plane of the body in a horizontal position and therefore they must of necessity result in internal rotation of the lower fragment.

A glance at Leyva's aëroplane splint will show this feature. Remains only an ambulant splint which, while permitting moving about, holds the arm in abduction and external rotation, the arm in the air, and a more uncomfortable position could not be imagined. Unless very carefully applied and carefully watched it might do more harm than good. It is entirely impractical.

These fractures of the head and neck of the humerus divide themselves pretty closely into three more or less distinct types. In the majority of cases only one type exists in any one case, but all may coexist.

CLASSIFICATION OF FRACTURES OF THE UPPER END OF THE HUMERUS

TYPE I.—Fracture of greater tuberosity without displacement (Figs. 3, 10, and 15). Subdivision A—with displacement of the fragments (Fig. 4). Both types may be complicated by subcoracoid dislocation. The shaft and neck are intact.

TYPE II.—Fracture of the neck of the humerus without displacement (Fig. 5). Subdivision A—with displacement of fragments, the head, however, remains in the glenoid (Fig. 6). Subdivision B—displacement of the head from its relation with the shaft. The head is also dislocated out of the glenoid.

TYPE III.—Fracture of the neck of the humerus with complicating fracture of the shaft of the bone (Figs. 7 and 8).

Type I. Fracture of Greater Tuberosity.—This is a very common type. There is not much displacement, and what there is, is easily overcome by a few days' treatment in external rotation. This type is well illustrated by referring to Figs. 3 and 10.

Subdivision A of Type I.—Fracture of the greater tuberosity is more extensive in degree, the entire greater tuberosity being split off and displaced backward (Fig. 4). Many of these cases can be co-apted by external rotation in abduction. Operation is required upon those cases in which this manœuvre fails and consists in tacking the tuberosity back into its place. Type I and its subdivision is frequently complicated by dislocation of the humerus—the force producing the injury to the tuberosity continuing through the intact shaft, forcing the arm into dislocation, the neck resisting the breaking force. In this type where operation is not required a few days, four or five, of extension, after reduction of the dislocation if present and immediate passive motion every day after the fifth. After the ninth or tenth day active motion. These cases should recover quickly with full range of motion. Some pain is likely to persist for a longer or shorter period of time, and is often due to subdeltoid bursitis.

Type II (Fig. 5).—The greater tuberosity resists the impact of the acromion. The force is transmitted to the neck of the humerus which gives



FIG. 3.—Type I case. Note how closely this case compares with Fig. 10.



FIG. 4.—Type I, subdivision A. This was an operative case, but general conditions prevented treatment demanded.

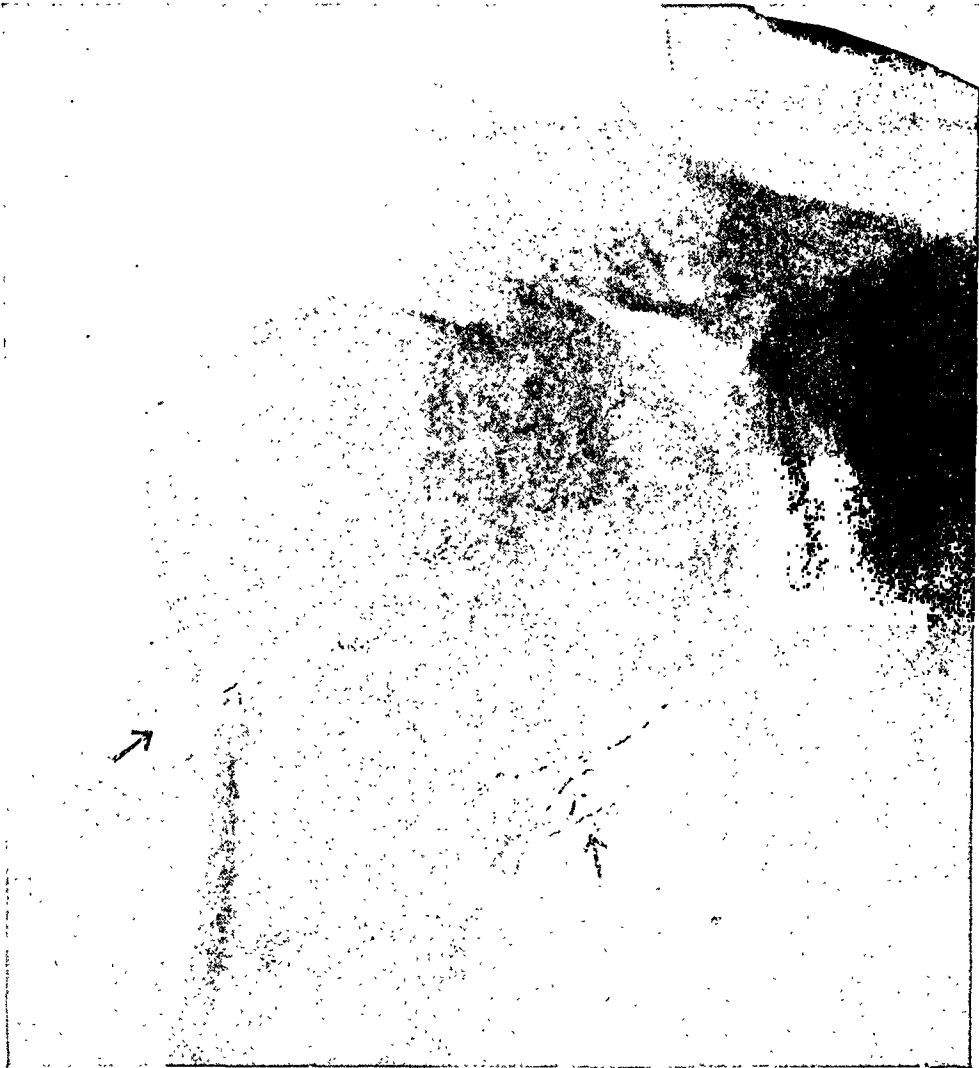


FIG. 5.—Type II: very little displacement.

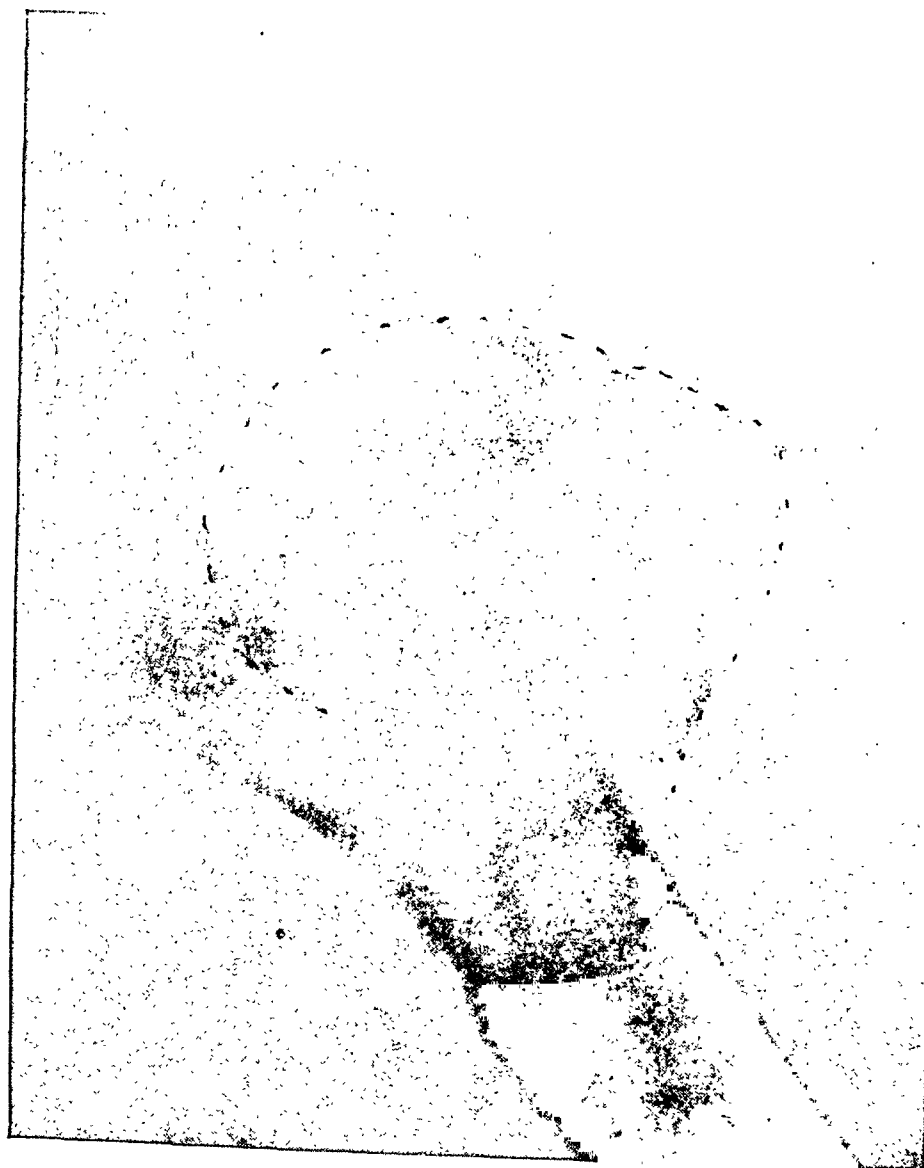


FIG. 6.—Type II, subdivision A.



FIG. 7—Shows Type III case. Fracture of neck of bone which shows badly in print. Also oblique fracture of shaft complicating the really important fracture at the neck. Shows overriding of oblique fracture. See Fig. 8.



FIG. 8.—X-ray of Type III case, taken on twenty-fifth day. Shows what was accomplished by traction and abduction with external rotation. Compare with Fig. 7 taken on day of injury.

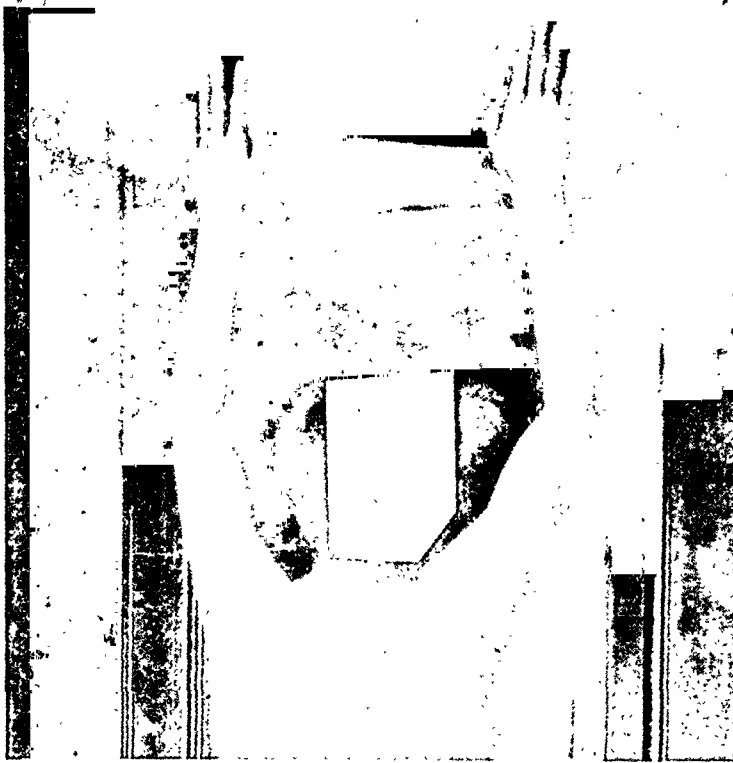


FIG. 9.—Showing motion obtained in case whose X-ray is shown in Fig. 3 on seventeenth day, the day of discharge. Some pain persisted afterward, but gradually ceased. Motion remained satisfactory. Slight degree of subdeltoid bursitis can be observed.



FIG. 10.—Type I case, showing simple fracture of greater tuberosity involving insertion of supraspinatus and teres minor. This case was treated by three weeks of restriction. The result is shown in Fig. 11, taken two and one-half years later, and shows the definite and permanent restriction in abduction which often follows this treatment even in these mild cases. Compare Fig. 10 with Fig. 3, which is almost identical, and compare Fig. 11 with Fig. 9, which shows the arc of abduction on the seventeenth day.

FRACTURES OF THE UPPER END OF THE HUMERUS

way almost transversely, many times with very little displacement and sometimes with impaction.

Subdivision A of Type II (Fig. 6) shows a very much displaced head, the head being drawn up by the action of the supraspinatus and externally rotated by the action of the infraspinatus and teres minor. The head of the bone is not dislocated in these two types. The neck of the bone has given way before dislocation, thus distributing the pressure, but the upper fragment is always rotated outward and many times abducted. Abduction and external rotation with block and tackle usually reduces this type easily and the abduction and external rotation with extension, eight to ten pounds, is the treatment in both forms of this type. Passive motion should be begun on the fifth day in cases without displacement, and thereafter treated like cases of Type I. Subdivision A of Type II should have passive motion not later than ten days after injury and oftentimes before this, and subsequent treatment is as in the other types.

There is a Subdivision B of Type II, fortunately rare, the head of the bone entirely separated from the shaft and also dislocated from the glenoid. The dislocation is subcoracoid in type because the dislocation is the first thing to occur, and the fracture of the neck is secondary to the dislocation, from the continuance of the leverage along an intact shaft, the head of which has lodged below the coracoid process of the scapula and is held more or less rigidly in its new position. This fracture is operative and requires oftentimes section of the tense subscapularis muscle before the head can be replaced in the glenoid. This type is of no special importance so far as the purposes of this paper are concerned. After operation the treatment would be much the same as that for the other types, but somewhat less rapid.

Type III (Figs. 7 and 8) is also fortunately rare and is in reality a different complex entirely, usually resulting from a more serious trauma than a fall with arm in extension. I have usually found it where the patient has fallen down stairs and a twist of the bone has been added to the other forces, causing a spiral fracture of the shaft complicating a fracture of the surgical neck and sometimes in addition a split-off greater tuberosity.

Treatment is the same as for the other types except that extension in external rotation and abduction is continued until twelfth to the fourteenth day. Coaptation splints are required for the oblique fracture of the shaft and great care must be exercised on instituting passive motion because of the broken shaft. The amount of weight necessary in these cases varies. It must be just enough to overcome the tendency to override and no more. Traction is discontinued after the arm is brought down to the side, as can be done by the twelfth or fourteenth day. Passive motion should be begun not later than fourteen days and active motion after sixteen days if care is exercised with the broken shaft. I have considered it absolutely safe, and have found it so in practice, to begin active movement by this time.

In these cases where recovery is slower than in Types I and II, most of the patients being elderly people (as is unfortunately true of all the other

types), I have found it advantageous in some cases, in order to prevent stiffening at the joint, to return the arm to the abducted position overnight every second or third night, but without extension, and to keep this up until active motion in abduction has reached a satisfactory point. Many of these cases present other complications which must be recognized. The treatment must not be blamed for failure to recover a useful arm if the musculospiral nerve is injured with resulting wrist-drop. This must be recognized from the start. The posterior circumflex nerve may be injured with resulting deltoid paralysis. Some of these cases show a deltoid which refuses to act at first, but which recovers rapidly after motion is instituted, showing that the nerve was not seriously involved.

We must also recognize that injury to the entire brachial plexus may also occur in these cases and also that in certain cases, as advanced by Codman, of Boston, the tendon of the supraspinatus itself may be caught between the acromion and the tuberosity and divided. This is recognized by absolute inability even to start the arc of abduction (Fig. 1). Later on we have subdeltoid bursitis and brachial neuritis and the results of a traumatic arthritis to contend against.

The treatment of these cases, roughly outlined above, is an interesting study and is an extremely simple proposition except in those cases where the shaft and the head cannot be coapted or where the head is also dislocated and separated from the shaft. The first procedure where there is deformity is a block and tackle to the lower arm in abduction, with the forearm flexed to release the tension of the biceps. The pull must be strong and steady, and while this is continued the arm is rotated into external rotation to correspond to the externally rotated upper fragment.

By means of manipulation the head and shaft can be coapted in nearly all cases, and where the greater tuberosity has been separated widely one will be astonished to find how closely it becomes approximated to its normal position. The arm is secured to the retention apparatus in this position, there being only one simple or efficient method for the treatment of this type of fracture in abduction and external rotation and that is treatment in bed, all advocates of ambulant apparatus to the contrary notwithstanding. With treatment in bed for some days varying with the type of fracture to be treated the position of external rotation is the simplest thing in the world and the patient is more comfortable than with any other method.

Some years ago when I first instituted this treatment I did so in fear and trembling. I had imagined a great amount of discomfort. I was agreeably surprised to find that I need not have worried. They are as comfortable as in any position. The splints which I employ are shown in Fig. 14, and the usual one used marked "A" is simply a right-angled wooden splint well padded. The arm is laid upon the longer side and attached to it not too snugly, the inner body end of this arm extending almost to the midline of the body. A pillow under the opposite shoulder prevents any discomfort to the patient. The forearm rests on the shorter arm of the right angle, extending

FRACTURES OF THE UPPER END OF THE HUMERUS

toward the head of the bed above the head and is held lightly with one or two cheese-cloth strips leaving the hand and wrist free for motion. Sometimes the wrist is tied to the head of the bed, but the hand is left free for use. A cord is suspended from the head board for the use of this hand.

In many of these cases, especially of Type I and sometimes of Type II, there is no necessity for splinting in the ordinary sense of the word at all. There is little tendency to displacement where the surgical neck is alone involved or in those cases of Type I presenting a simple fracture of the tuberosity where there is no displacement. Simply placing the arm in abduction and external rotation is all that is required for these cases. The important part of the treatment is the traction of seven to ten pounds for the first four or five days, the arm in abduction and external rotation resting simply on a firm pillow splint. Traction is secured by means of plaster strips along the arm extending high up to the fracture or by means of a sling about the arm, forearm and splint at the elbow.

This treatment accomplishes its object in several ways:

First, it is the necessary treatment in all cases of arthritis, as has been so ably advocated by Murphy of Chicago. And every case of this kind, no matter how simple it may seem, is a case of arthritis. The joint is always involved, is always traumatized and nearly always full of effusion and blood. Extension puts the joint at rest, prevents the traction of the various muscles and relieves the tension inside the capsule. The treatment accomplishes another equally important thing. It starts treatment in abduction above a right angle, and therefore it is a much simpler matter to get the arm back into this position later when active and passive motions are begun. Some of these cases presenting apparently slight damage, show later an excessive amount of callous formation which if allowed to calcify absolutely prevents the tuberosity from sliding under the tip of the acromion, the callus impinging on the acromion after the arm has swung beyond a right angle. Full abduction in these cases becomes an impossibility and this loss of motion is permanent (see Fig. 15).

With the bones in the position of abduction and external rotation and by passive motion early this tendency if present is overcome, the soft callus is planed down as it were and rarely becomes of serious importance. In the minor cases the arm is gently moved in passive motion after the fourth or fifth day and traction is discontinued on this day, the arm brought to the side, gently rotated inward, and the forearm supported by a sling, the arm being held to the side with a wide swathe. If we could be sure of coöperation and care by the patient the swathe could be discarded in these cases. It appeared to me at first that extension was hardly necessary in these mild cases—that passive motion early would accomplish the purpose equally well, but I have come to believe that the extension even in these mild cases is equally important with early motion, and that the more serious types apparently recover under this treatment almost as rapidly as the others. In other

words, it is the injury to the joint and not the fracture; and the simple types have injured the joint structure sometimes quite as much as the others.

Sometimes I have thought that in the pre-X-ray days, when this lesser type of injury to the shoulder was probably not recognized as a fracture, and therefore not treated as one, the recovery was most likely quicker than it has been since we have had the X-ray to aid us. Since we have had the X-ray and under the usual treatment these cases have not recovered the functional use of the arm much more quickly than the more seriously injured and nearly all of them have presented permanent impairment of motion months and even years afterward. Fig. 10 represents a case of this kind—a Type I injury which was treated by a good surgeon. Swathe and sling for three weeks only—and I have seen many treated by restriction for much longer periods—yet this was quite long enough to do the damage. Fig. 11 shows this case and the permanent restriction of motion two and one-half years after. He has never recovered full abduction. Compare Fig. 10 with Fig. 3 and you will see the remarkable similarity of the pathological process. Fig. 9 represents the amount of active motion which was obtained in the case represented by Fig. 3 (a Type I case) in seventeen days by our method of treatment. This case was discharged on the seventeenth day. There has been some pain on active motion which will gradually wear away, but there is little restriction to motion itself.

I believe the extension is the important factor at first, and that at any rate it lessens pain in motion later. Active motion (slight at first) in abduction after the seventh day. Rotation movements are usually left to the last and are carried out gently but actively after nine or ten days.

Some of these cases will show limitation of motion due to a subdeltoid bursitis for some time, and pain to a certain degree is to be expected for a time (Fig. 9).

The treatment by traction and abduction is to my thinking the best preventive for this condition, and I have found this complication less frequently since I have used it. In the more serious cases the treatment is very much the same. (Figs. 5, 6 and 7 represent these types.)

In case represented by Fig. 5—Type II case—passive motion was begun on the sixth day, but not the full range, and gradually increased in extent; active motion after the seventh day, but restricted at first. Final result of motion is shown on thirtieth day by Fig. 12. Case represented by Fig. 6—Type II case—Subdivision A, presented difficulties in reduction, but once reduced the treatment was as simple as the others, motion being begun somewhat later, and later than I now begin it even in this type. Passive motion on twelfth day and active motion a few days later. Fig. 13 shows the result in this case and represents the degree of motion attained on the thirty-second day.

Fig. 7 represents a much more serious injury—Type III—the break through the surgical neck being complicated by an oblique fracture of the shaft of the bone with overriding. This case was treated on the right-angled

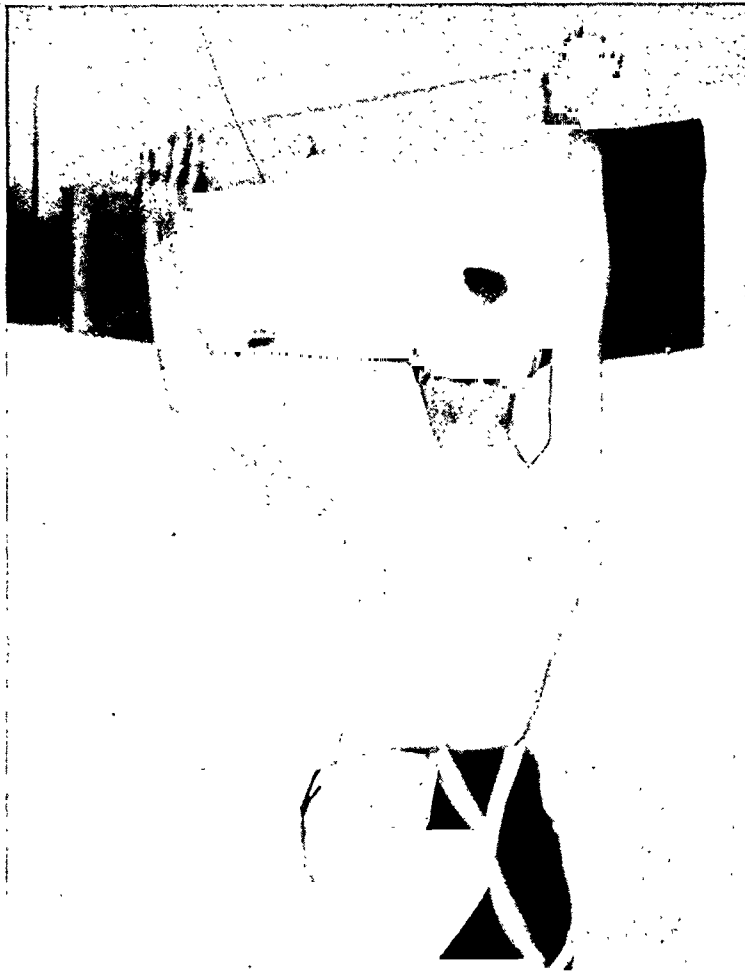


FIG. 11.—Two and one-half years after injury under old treatment. Permanent restriction in abduction and external rotation.

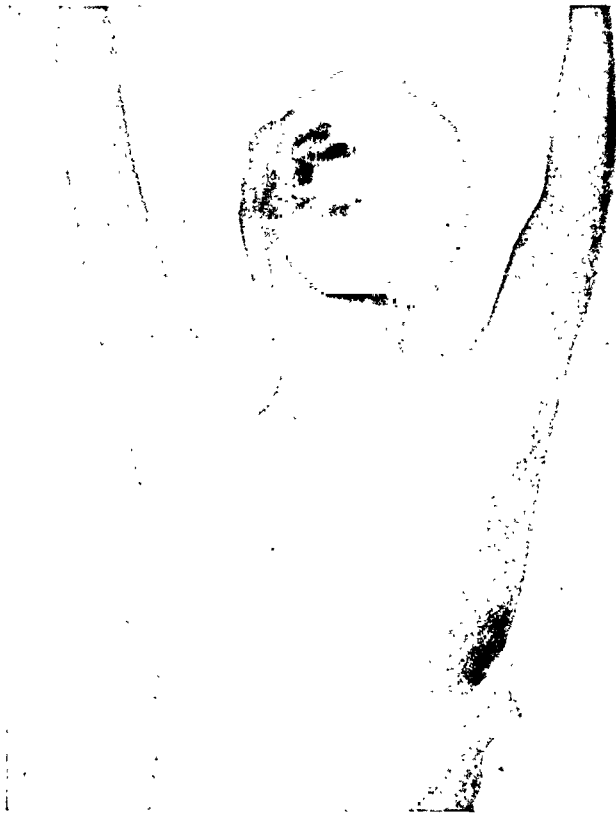


FIG. 12.—Shows motion obtained on thirtieth day. Pain in this case was considerable. Worse at night and persisted for some months, but motion was satisfactory from the first. X-ray of case shown in Fig. 5.

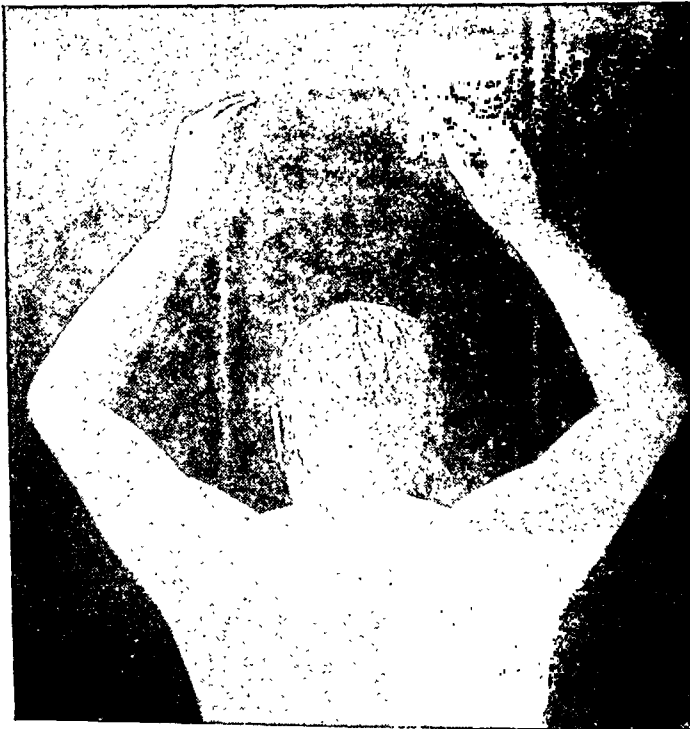


FIG. 13.—Type II, subdivision 4, showing motion obtained in Fig. 6 on thirty-second day. Equally good motion shown earlier than this, but photograph is thirty-second day. Pain not pronounced in this case.

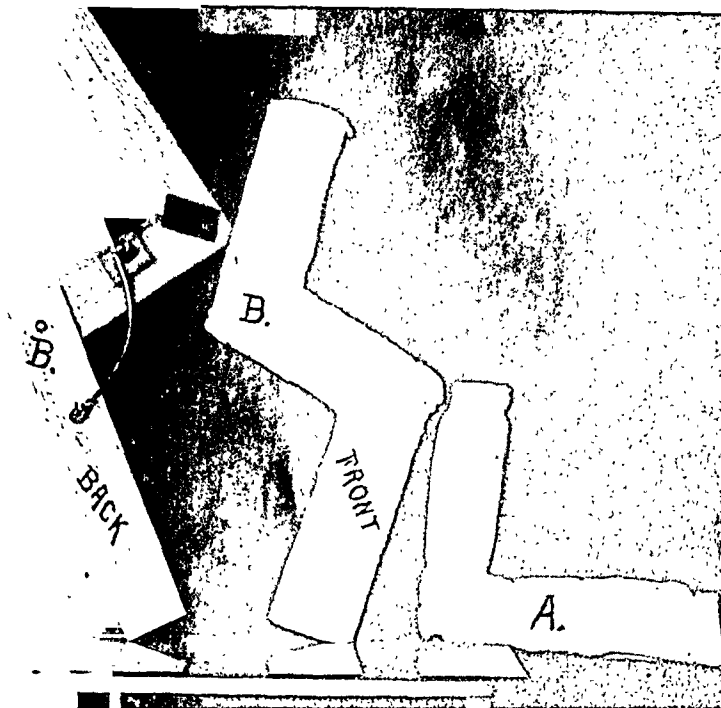


FIG. 14.—Shows splints which we use and call our own. *A* is splint used in nearly every case. *B* shows back and front of special type which we have used in special cases, but it possesses no advantages over the simple right-angle boards.



FIG. 15.—Note excessive callus after Type I case. This callus impinges on the tip of the acromion process, and makes abduction above a right angle an impossibility in this case. This should have been prevented.



FIG. 16.—Shows right-angle splint in place with extension to arm. Head of bed raised on extension side. Splint A, Fig. 14, used in this case. X-ray of this case shown in Figs. 7 and 8. Final results shown in Fig. 18 on thirty-first day.



FIG. 17.—Showing active motion in Type III case on twentieth day. X-ray of this case shown in Figs. 7 and 8.

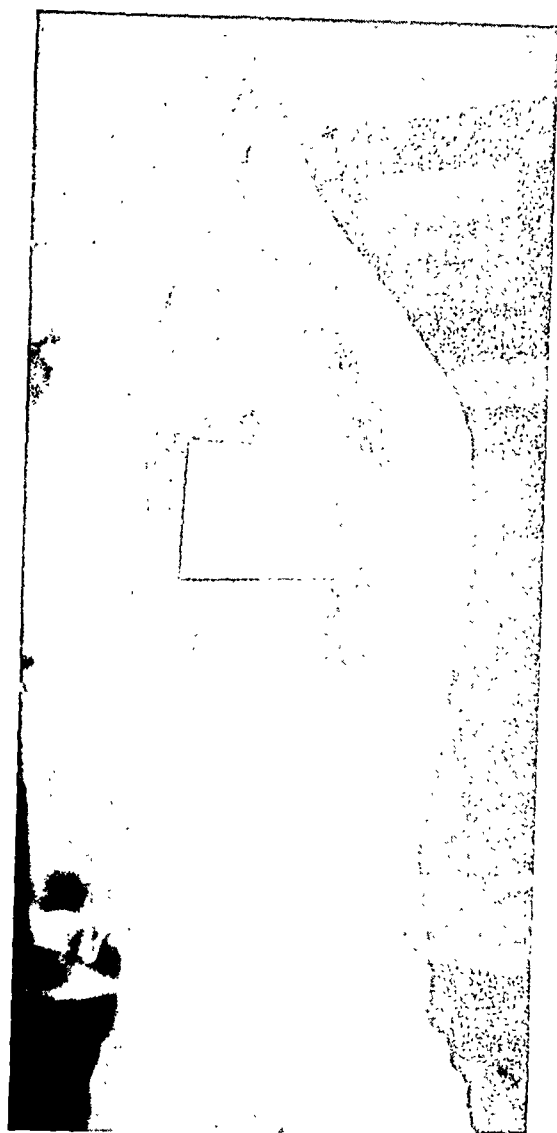


FIG. 18.—Type III case, showing active motion on thirty-first day. X-ray of this case shown in Figs. 7 and 8. Pain negligible in this case.

posterior splint, arm in abduction above a right angle and external rotation with an extension of eight pounds for twelve days. Fig. 8, which was taken twenty-five days after the original injury, contrasted with Fig. 7 will amply demonstrate what the extension accomplished. The splint A of Fig. 14 shows the splint used in this case and the one which we usually use. The other shown—B Fig. 14—is a type which we have used in special cases, but the one shown in A is the one which we prefer. This permits of passive motion at the shoulder while in place, and after the first six days the shoulder was gently moved for a few inches each day with the apparatus in place.

Coaptation splints to the broken humerus were used in this case, and on account of an extremely tender skin traction was obtained from a sling at the elbow instead of plaster along the arm, which is the better method because it permits free motion at the elbow during the period of confinement in bed. The apparatus in place is shown in Fig. 16. Treatment on account of the oblique fracture of the shaft was necessarily slower. The arm was moved a few inches each day after the sixth day. On the twelfth day, the arm, still in the splint, was brought down to an angle of thirty degrees, with the arm traction still in place, the forearm raised from the bed somewhat so as not to lie flat, because as the arm comes down in abduction the external rotation must be made less and less. The whole bone moved in continuity on this day.

Twenty-four hours later the arm was brought to the side, the splint and traction discarded, the arm gently rotated into internal rotation, and from this time on the patient was up and about—the forearm supported by a sling, the arm held to the body by a swathe. The coaptation splints were left on for some days longer. Passive motion was begun on the fourteenth day and on the sixteenth day passive motion almost to the full arc of abduction was reached. Active motion was begun on the sixteenth day, gently at first. Active motion was slow in returning, but Fig. 17 shows the degree of active motion on the twentieth day, and Fig. 18 shows the result at end of thirty days.

I have had occasion before to bring forward the contention that in fractures involving joints we have for years been making the most egregious blunders in the treatment, and our results have been atrocious.

A splint is of value only as a temporary support until enough callus is formed to prevent deformity. After that a splint is an injury. It is of use only until such time as the soft callus has formed sufficiently to protect the ends of the broken bone from again becoming dislocated and this period is very much sooner than we have been accustomed to believe. Of course no strain must be put upon the bone at this early date, and in lower extremity fractures it is a long time before actual weight can be borne, but the necessity of splinting, save that necessary to prevent injury by the patients themselves, passes very quickly, and in intelligent people who will exercise a certain

degree of care, fractures which do not involve weight-bearing will recover much more quickly if this rule is applied.

Actual bony trabeculæ are demonstrable across the broken surface as early as the twenty-first day, and enough stability is present long before this to permit of motion necessary to prevent the long tedious months of recovery which ensue when a joint that has been traumatized is locked up for weeks.

A Colles's fracture, even if properly reduced, if left in a splint after the tenth day is a case maltreated. Motion instituted from the first and removal of splints early will give surprising results. A Colles's is no longer a question of months: it is usually a matter of days. The same applies to a Pott's, save that here we must be careful of the weight-bearing and the weight of the foot itself—but early motion should be the rule.

The same reasoning and execution applied to fractures of the upper end of the humerus will give results which are no less satisfactory to the surgeon than to the patient and will save many an arm from partial disability.

CONCLUSIONS

1. Fractures of the upper end of the humerus, *i.e.*, above the insertion of the pectoralis major muscle, will in nearly all cases conform to three types and their subdivisions. All should be treated in abduction and external rotation with traction varying from a few days in mild cases to twelve days in complicated ones.

2. Passive motion must be begun early and active motion must follow very quickly if we are to prevent the tendency to restriction of motion. It must be used always with care and with due regard to the anatomy and pathology. In the mild cases it is safe to begin very early since there is little tendency toward displacement.

3. A right-angled wooden splint in the severe cases and a firm pillow splint in the mild cases always with traction is the ideal method of treatment.

4. External rotation in abduction as a treatment is almost an impossibility of accomplishment unless the patient remains in bed. In bed it is the simplest method and not an uncomfortable position for the patient.

THE USE AND VALUE OF THE LANE PLATE

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IN view of the great interest evinced in the treatment of fractures during recent years, and, particularly, from the stimulation imparted to this study from the experiences of the war, I venture to present my personal view on one phase of the question of open operation for fracture of the long bones. I refer, specifically, to the use and value of the Lane plate as a method of fixation and immobilization. The individual surgeon is apt to deduce general conclusions from too few available facts. It is solely by a compilation of individual experiences and general debate of the topic that the truth gradually and finally crystallizes.

In the beginning of this discussion, I may frankly state that I am an advocate and partisan of the use of the Lane plate in certain types of fractures, particularly, fracture of the shaft of the femur, of the tibia and of the humerus. This conviction is based upon a series of sixty-two open operations for fractures. In the tabulation of this series, I have excluded all cases of fracture of the patella, because the surgical treatment of this type seems well established and generally accepted. Also, all cases of compound fractures are excluded. These sixty-two operations, then, are, in the main, open operations for simple fractures of the humerus, femur, tibia, radius and ulna. The methods employed for fixation were the Lane plate, silver wire, kangaroo tendon, nails, bone-graft and fascia lata. The Lane plate was employed thirteen times.

It must be recalled that in strong, robust and muscular individuals, with either a fracture of the femur, the humerus, or the tibia, presenting great displacement and over-riding and necessitating an open operation, a method of fixation must be employed which guarantees the successful reduction, in order that the advantage derived is not lost; and, that the patient is not exposed to a grave operation, solely, to have the immediate result and benefit vanish when the skin is sutured. In a word, if the method of fixation employed does not effectively maintain and rigidly secure the reduction, the patient is needlessly exposed to the danger and jeopardy of an open operation. It is almost unnecessary to call attention to the danger of open operation in which the aseptic technic is faulty. The risk to life and limb is too great to warrant undue experimentation.

From an ideal viewpoint a fixation apparatus capable of absorption should be the best. The introduction of foreign material, particularly, metal, into an open wound, does not appeal to the surgical mind. Ingenious contrivances and methods have been devised for the purpose of avoiding the

metal. This effort has been mainly in the direction of the invention of absorbent plates, screws and pegs of ivory, magnesium, decalcified bone, etc. Despite this, no commendable method exists which splints a bone so firmly as the use of steel plates and screws. Kangaroo tendon has been widely used for this purpose. While this material is excellent for a fracture of the patella, or to suture the radius, or the ulna, it is not sufficiently strong to maintain the reduction of the femur, the tibia, or the humerus. Even in a child, these bones are too large and heavy, and the muscles of the arm, the leg and the thigh too powerful for suture material so fragile to withstand. The same consideration underlies the use of chromic catgut. On one occasion, I used a long, narrow strip of the fascia lata, passed through two drill openings in the shaft of the femur. This patient, unfortunately, developed diphtheria several weeks later and was transferred to the Willard Parker Hospital. Owing to faulty records and failure to find the patient, the ultimate result cannot be stated. As a matter of interest, I may mention in passing, that this operation with fascia lata was done prior to the time—at least a year—when John B. Roberts called attention to this method of fixation.

My personal experience leads me to believe that certain types of fracture can be reduced and immobilized only by using the Lane plate. It is widely known that the use of the Lane plate is generally decried as being dangerous and uncertain. Indeed, many surgeons speak and write of it in scathing terms, and from a superficial study of the subject one might infer that the procedure is universally condemned as being unsurgical and dangerous. That it is not perfect, one must admit. The substitutes recommended may not always be effective and innocent. Incidentally, numerous therapeutic measures of acknowledged benefit and value, are not always one hundred per cent. efficient.

The objection, prominently advanced, is that the Lane plate delays callus formation and bone union. The validity of this objection is, admittedly, based on clinical experiences. But all methods of fixation, particularly, those using metallic objects, are open to this criticism. Indeed, it must be recalled, in fact, reiterated constantly, that no means of open operation for fracture hastens bone union, a cardinal point, generally overlooked in the discussion of this matter. The sole object of an open operation is to secure anatomic reduction of a bone. There is no method of fixation which hastens bone union or callus formation. Clinical observation and practical experience, in open operation for fracture, demonstrate that no method of operative fixation, or immobilization, using any form of internal splinting apparatus whatever, hastens the union of bone. An open operation is employed solely to reduce the bone to the normal outline and contour. Regarding the length of time necessary for the production of strong union, it is even possible that an open operation prolongs the period of union. Indeed, this is not an uncommon occurrence. But the delay of one or two weeks cannot be sufficient to militate against the selection of the operation. In

fact, as a patient may not be able to walk and use the limb with freedom and comfort for many months, despite any treatment employed, a matter of a few weeks is relatively unimportant.

An undue delay in union is emphasized by a bending or yielding at the site of fracture, at the end of the fifth or sixth week, a time when at least moderately strong fibrous or bony union should exist. The delay in union is generally ascribed to the presence of the foreign body maintained for the purpose of immobilization, a statement which is unquestionably true. In short, the Lane plate, while overcoming and preventing deformity, occasionally causes delayed union. If this takes place, no time should be lost in removing the plate. Under these circumstances, one generally finds that the Lane plate and the screws have been carried outward towards the skin incision by the expansion of the enveloping callus. This fact, combined with the natural atrophy of the muscles from the immobilization in plaster, places the plate and screws close to the incision. It is not difficult, therefore, quickly to remove the plate; local anæsthesia is generally sufficient.

It is important, in this connection, to emphasize the fact that the delay in union, seen in the use of the Lane plate, with the bending and buckling of the bone and the excessive callus formation, takes place just as often, possibly, following the use of silver wire. And in these instances of delayed union, following the use of silver wire, the silver wire, also, must be removed if firm union is desired; but, the removal of the silver wire is, as a rule, accomplished under great difficulties, because it tends to remain deeply buried in the centre of the callus.

Silver wire is the most widely used of all the means of metallic fixation. It possesses sufficient tensile strength and has an inherent antiseptic quality, due to the metallic silver. Several modifications have been advised, such as picture wire, bronze wire, etc., but in general, the fundamental principles are the same. The opponent of the Lane plate is ultimately forced into the position of becoming an advocate of silver wire. From my own experience, however, I have never yet seen a case in which silver wire has been used but some degree of angulation occurred. In a word, though silver wire prevents, as a rule, longitudinal displacement, it does not assure sufficient stability and rigidity to overcome the lateral deformity. As a result of this uncertain fixation, angulation and bending are prone to take place. One will recall that this is an objection to the Steinmann nail method.

There exists, perhaps, a technical reason for the angulation. While the introduction of silver wire through two drill openings is an extremely simple procedure, the twisting or tightening of the wire is not so easy. This step must be done with extreme caution, lest the wire break if tightened too suddenly, or to a point too extreme. It is possible, in some instances, that the silver wire has not received sufficient twisting, leaving, as a result, more or less slack within the suture. Even in the hands of experienced men, the twisting of the wire being carried to an extreme point, angulation will take place. If this angulation occur in a lateral and external direction, a direc-

tion favored, for example, by the normal outward bowing of the shaft of the femur, it is possible that the fragments may ultimately come in contact with the skin. Indeed, if the angulation be extreme, the bony fragments may rupture and protrude between the margins of the incision. This unfortunate accident is in no way occasioned by the occurrence of infection. It is natural, however, that when the fragments reach or rupture the incision, that a subacute inflammatory process will supervene, the recognition of which is extremely difficult. The X-ray is of but slight value in showing whether the fragments have ruptured the incision. If the angulation appear unduly extreme in the picture, or the temperature persists above 100 at the end of ten days, the cast should be removed and the limb closely inspected. The treatment of this complication consists in the removal of the silver wire. Once having been exposed to the air its removal is imperative.

In children silver wire is, perhaps, the best means of fixation, because they are not good operative risks and their tissues do not withstand so intense a degree of irritation as the adult. Moreover, if angulation take place in a child, the compensatory change and growth of bone overcome and correct the deformity. In regard to the development of a sinus, no doubt exists that silver wire, in many instances, produces a sinus which can be cured only by the removal of the wire. Under these circumstances, one is compelled to perform a secondary operation. Unlike the Lane plate, the wire tends to remain buried at the bottom of the callus, which must be chiselled or removed. This secondary operation greatly impairs the integrity of the union derived from the primary operation.

The Parkhill clamp has been, admittedly, of great value in the stimulating and devising of means of internal fixation in fractures. Though the clamp has been generally discarded, numerous modifications, based on the original principles, are, at present, widely employed. Though effective in holding the fractured bone in proper alignment, they possess in general a marked and distinctive feature, in permitting direct and continuous communication between the fracture and the external air, a point of technic directly opposed to the cardinal principles of asepsis and normal wound healing.

I have never used a bone-graft for a fracture of the shaft of the femur, because it seems to me that the physiological principles of this operation have never been clearly enunciated. That the bone-graft is distinctly incorporated and forms an integral part of the femur, has not been clearly demonstrated. If it is used solely as a means of fixation, the patient is exposed to the second danger of an accessory operation. Moreover, the danger of fat embolism is greatly increased. As the use of the bone-graft seems to rest ultimately on its capacity to stimulate osteogenesis, the risk included in the operative technic outweighs whatever advantages, productive though they may be, that the operation presents.

An open operation should seldom be performed for fracture of the femur in a child. The condition existing in a child is by no means analogous

to that in an adult. Also, a plan of treatment based on a reading of, or interpretation of X-ray pictures, may lead to the selection of the wrong method. In short, there may exist in a child a degree of overlapping of the fragments, which, if present in an adult, would definitely decide the necessity of an open operation; but, being in a child, in whom the condition of bone growth and compensation are so strikingly different, conservative treatment, and not the radical, should be instituted. This capacity of adjustment is due, or rather, receives its source, from the active, growing epiphyses. The bone being a vigorous, growing organism, appears to possess the capacity to compensate for any fortuitous shortening. In a child, therefore, with a fracture of the femur and excessive overlapping and displacement of the fragments, the union and result may be excellent, despite the original shortening. It is essential to keep this point clearly in mind.

In addition, there should be no cosmetic deformity. If a fractured limb, on inspection, appears to possess the normal contour, shape and size, it is probable that the ultimate outcome will be satisfactory. This rule has certain exceptions; but, in general, it can be used as a practical working guide. In the adult, however, the interposition of the muscular tissue between the ends of the bone is an extremely common occurrence and one prone to lead either to difficulty in the proper reduction, or failure of union.

A Lane plate represents the quintessence of aseptic technic. Those who have had the pleasure of seeing Sir Arbuthnot Lane operate must appreciate the painstaking and perfect work accomplished by this brilliant surgeon. The cardinal point in his impeccable technic, is that no finger or hand touches the gauze, the instruments, the plates, or the screws—in fact, anything employed in the operation, from the time of leaving the sterilizer until entering the wound. In many hospitals, it is impossible to introduce the Lane technic, save under great difficulty, owing to the rapid alterations in the personnel of the house staff, the constant changes in the nursing organization and the absence of standardization of technic. Certain important points, however, may be utilized.

The surgeon cannot be too meticulous in his demands and exactions. Of course, he and his assistants, including the nurses, should wear masks and rubber gloves. It is important that conversation be reduced to a minimum. Indeed, strict silence is enjoined, for it accelerates the operation. Before proceeding with the operation, the nurse in charge should be consulted, to ascertain definitely that the proper plates, screws and instruments are available. A particular point to be observed is that a drill of correct size and length is at hand. Great confusion may arise during operation from failure of the surgeon to determine previously that the necessary drill is available. The limb should receive careful preliminary preparation. It should be scrupulously cleaned, washed and scrubbed with ether, alcohol and benzine and painted with iodine. When the draperies are removed upon the table, one painting of iodine is sufficient. The surgeon should so arrange the time of operation that no appointments or engagements urge him to undue haste.

If possible, the Lane technic should be religiously followed. Two knives are used. The skin being considered a septic surface, the scalpel used for it is immediately discarded when the deeper structures are reached. The sterile towels are then clamped to the margins of the wound, so as to prevent an exposure of the surface of the adjacent skin. Allis clamps are extremely serviceable for this purpose.

A long incision is desirable. The manipulation of the bones is facilitated and vigorous retraction avoided, thereby, preventing undue traumatism to the soft parts. Moreover, if a long incision is made, it is not necessary to change the position of the draperies and the towels, in case the incision needs to be prolonged. The fascia lata is incised with the scalpel, making a clean incision. The muscular masses are best divided with a blunt instrument, preventing thereby, unnecessary division of the large arterial branches, and lessening, to a certain extent, the hemorrhage. As the wound, particularly in the thigh, is extremely deep, broad abdominal retractors serve best to expose the site of fracture and to identify the fragments. The periosteum may be disregarded during the manipulations necessary to free the fragments. This point, brought into prominence by Lane, receives confirmation and support from actual practice. An essential error in the technic is the violence and vigor employed in the manipulation of the bones. This entails undue force, favors tissue destruction and, incidentally, infection. The reduction should be made with a minimum of effort. In order to accomplish this the surgeon must endeavor to detect the restraining causes. These mainly consist in interposed fascia, periosteum, blood-clot and muscle. These structures should be pushed aside, if possible, to avoid the direct incision of the soft parts. To effect reduction the muscles should be freed from the shaft over a certain area close to the fractured ends. The extent of freed muscle-mass must be as short as possible.

The fragments, as a rule, are separated by organized blood-clot, fibrous tissue, periosteum, or numerous muscular slips. This interposed tissue should never be excised or cut recklessly. The close proximity of the shaft of the bone to the large arteries and nerves, does not permit an injudicious use of the scalpel or scissors. Each bone fragment should be isolated. In operating on the femur, I have noted that after the muscles have been separated, it is occasionally difficult to see the fragments. As a rule, one fragment comes into view. This fragment should be carefully exposed and cleaned, so that it can be mobilized. When this has been accomplished, the second fragment may be exposed. The ends are cleaned by mild scraping with a curette and all adventitious and fibrous bands removed or pushed aside. One should be extremely careful not to curette the open medulla too vigorously, for fear of causing fat embolism, an incident not uncommon in operations upon the shaft of the femur.

During the operation one assistant should hold the foot, in order to exercise traction, extension or flexion, as the surgeon directs. It is imperative that each fragment should be well mobilized before reduction be made.

USE AND VALUE OF THE LANE PLATE

Heavy bone forceps of the Lane type greatly facilitate the moving and lifting of the bones. Following reduction, the fragments are held in alignment with Lowman clamps, while the plate is adjusted and the screws introduced. The Lane plate is placed over the anterolateral surface of the shaft of the femur. A revolver bone drill makes a small depression for the entrance of the screws. Four screws are generally sufficient to hold a femur, though the plate is made for six, or even eight screws. It is best to use as small a plate as possible. Following the introduction of the plate and screws, the muscles are allowed to come together. The fascia is sutured with continuous catgut and the interrupted catgut for the skin.

A subtrochanteric fracture of the shaft of the femur furnishes an ideal indication for a Lane plate. There is no method of treatment which has the power and capacity to maintain immobilization in this type of fracture so efficaciously as the Lane plate. It is well known that a subtrochanteric fracture of the shaft of the femur is extremely difficult to reduce, the pull of the large thigh muscles being hard to overcome. Also the natural displacement, due to muscular contraction and retraction, offers peculiar difficulty to the proper reduction. I have, therefore, come to the conclusion that this type of fracture is one especially suitable for Lane plating. There are certain precautions, however, that one should observe in the routine use of the plate. The patient should be under forty years of age, strong, robust and in complete health.

A comminuted fracture of the shaft of the femur is not, as a rule, suitable for open operation. One generally finds that the fragments are so extremely splintered and short, that when grasped with a bone forceps, they easily break. This, naturally, prevents or even offers great difficulty in the proper reduction of the bone at the time of operation. The removal of these fragments, however, is a procedure fraught with great danger. I have seen instances where their removal caused non-union. Many of these fragments being triangular in shape and tapering to a thin edge, great care is needed in applying the holding bone forceps, for they may divide or break the fragments. Moreover, one finds great difficulty in introducing screws, nails, or wires.

Open operation for fracture of the shaft of the humerus is not as often indicated as in the femur, because a slight angulation or overlapping may exist, without disturbing to any appreciable degree the functional use of the arm. If, however, the swelling and deformity are extreme and one has reason to believe that marked over-riding exists, an open operation is indicated. A plate effectively holds the fragments in position. Two or three screws are at most needed. Care must be exercised to place the incision at a point where there is no danger of wounding the musculospiral nerve.

The Lane plate has a distinct field of usefulness in certain fractures of the shaft of the tibia, that defy reduction by traction or manipulation. It is not unusual, in fractures of both bones of the leg, to find that despite vigorous traction and manipulation on a Hawley fracture table, proper reduction

does not take place. Not only is the cosmetic appearance bad, but the X-ray verifies the displacement. In some instances, the reduction is prevented by the fragments, either the upper or the lower, passing between the opposite two. This type of fracture offers the Lane plate an excellent opportunity of success. Occasionally, however, in these cases, the Lane plate must be removed. One generally finds that during the period of healing the incision softens and separates, exposing the Lane plate at the bottom of the wound. The wound is permitted to granulate. There is generally no elevation of temperature or undue disturbance to the patient. Occasionally, but rarely, a slight sub-infection persists, despite the removal of the plate. This seems to arise from proliferation of the periosteum. The test of the applicability of the plate is that it restores the bone to its normal contour.

The patient should always be operated upon on a Hawley fracture table. It is essential that before the operation begins the surgeon adjust the patient to the table and have the companion limb bandaged to the foot-piece, so that the operation can be conducted expeditiously. In fact, it is better to cover the pelvis with cotton or flannel bandages before the operation so that no time is lost, or the position of the patient changed, in order to remove the dressing.

In the case of fracture of the femur, the patient at the end of the fifth or sixth week, is brought to the operating room and the plaster cast carefully removed, the catgut sutures are brushed away and the wound is cleaned and dressed. It is then preferable to apply a long, moulded, plaster splint, avoiding, incidentally, the compressive effect of a plaster cast. In this way, any tendency to pressure or bed-sores is obviated. The patient is kept in bed as long as possible, because the longer weight-bearing is postponed the better the final result.

Following an operation for the introduction of a Lane plate, the post-operative course should be carefully scrutinized. The temperature curve is of great importance. At times it is difficult to differentiate between a true infection and the development and manifestation of an ordinary wound-healing, associated with a large blood-clot. The detection of the presence of infection in the wound should be early, in order that prompt treatment may be instituted. One must recall, in this connection, however, that the post-operative complications incidental to any operation, may take place in this instance, necessitating careful and keen diagnostic discrimination. A daily supervision of the patient's condition, the pulse rate, the state of the tongue, whether pain is complained of, are particularly necessary. A prolonged elevation of temperature is extremely significant. The temperature following an open operation, in the case of an aseptic healing of the wound, reaches a low point about five days following operation. If the temperature persists after the sixth day, gradually attaining a maximum range of 103° , the presence of infection in the wound is extremely probable.

Owing to the migratory habits of the patients, it has been impossible to follow up the cases in detail, in order to determine the ultimate end-results.

Nevertheless, many of these patients have been observed for many months, while of some I have records extending several years, but owing to the somewhat incomplete end-studies, no attempt is made to furnish a complete statistical analysis. In this series of open operations, there are but two unfortunate results. In one a secondary operation was performed, while in the second, death took place from acute dilatation of the stomach. In the first, a young man with a badly displaced fracture of the femur, a Lane plate maintained perfect reduction of the fracture. At the time of discharge from the hospital the limb was in excellent condition. At a later date, however, he returned to the out-patient department, presenting excessive callus at the site of fracture and a marked bending of the bone. Naturally, he had employed too early weight-bearing on the limb. An oblique osteotomy of the shaft of the femur was employed for the correction of the deformity. A resulting atrophy and paralysis of the muscles of the leg, however, led to an exploratory operation in which the sciatic nerve was exposed and freed from excessive callus. A neuroma was encountered and excised and an end-to-end union made between the trunk of the sciatic nerve and the internal and the external popliteal nerves. The patient was later studied in detail, from the neurological viewpoint, by Dr. Joseph Byrne, who discovered distinct signs of regeneration, as evidenced by the return of protopathic sensibility. A trophic ulcer of the foot, however, became so progressive, that a modified Chopart amputation was done with excellent results.

In the second patient, with an extremely comminuted fracture of the upper one-third of the shaft of the femur, extending into the great trochanter, a final reduction was obtained by introducing a Lane plate. The wound became mildly infected, though no severe infection existed in the bone. The patient finally died from acute dilatation of the stomach, a diagnosis confirmed by autopsy. Upon reflection, it is evident that an open operation should not have been attempted. The extensive comminution and splintering absolutely precluded any attempt to restore the normal contour. The experience supports strongly the contention urged above, that a comminuted fracture of any degree should not be operated. The forcible efforts required to secure reduction caused, no doubt, a certain devitalizing of the tissues, which in turn favored the infection.

It is frankly admitted that the treatment of fractures in a general hospital is usually an exceedingly neglected subject. The enthusiasm and the ardent desire of the younger members of the staff for abdominal surgery, so spectacular and dramatic, and the general lack of equipment, such as beds, splints, fracture tables, etc., constitute the main reasons.

Great benefit may be derived from a definite system of treatment. The immediate first-aid treatment is, admittedly, beyond the control or the direction of the hospital. The duties of the ambulance surgeon, however, and the method of treatment employed by him, can be, to a certain degree, directed and systematized. For fractures of the extremities, plain lateral, wooden splints, neatly padded, are the best means of temporary immobiliza-

tion. The patient is brought to the hospital, as soon as possible, where he is referred to the house surgeon for the secondary or interim treatment. The wooden splints should then be removed and moulded plaster splints applied. In any case, the crucial point is that a temporary method of absolute fixation and immobilization is needed and that the usual means employed, the wooden splint, is at the best but a makeshift. It should be used but for a few hours, at the most, for if allowed to remain for a longer period, there impends the danger of pressure sores at the site of fracture, from the unyielding nature and hardness of the wood. Furthermore, wooden lateral splints tend to slide and slip, rapidly assuming a position the reverse of that in which they were originally applied, while the moulded plaster splint is quickly made, and affords the patient great comfort.

The preliminary method of immobilization is an important factor before the definitive treatment is selected. Undue displacement and movement are prevented and the patient transported with ease from his bed to the X-ray department. If marked swelling and bleb formation occur, wet dressings may be applied over the moulded plaster splints. The patient is then X-rayed and the plates studied by the visiting röntgenologist. The actual physical examination is generally postponed until the patient is anæsthetized, which is always done for reduction, whether simple or open. The physical and local symptoms are determined when the patient is under the anæsthetic and then carefully described and noted on the history chart at that time. Accurate measurements are also taken and recorded. Owing, however, to rapid changes of internes, absence of central control and to differences of opinion regarding treatment—in short, from lack of standardization, it is impossible to execute a specific plan, and will not be possible until a hospital service is conducted with the same efficiency as a factory—until the scientific parallels the industrial—that we shall have the ideal end-results.

The lessons we have learned, however, from the war and the discipline which has been instilled into our colleagues, will ultimately redound to the credit of the profession and influence, unquestionably, the future work and arrangement of the hospital staff. The effort toward the introduction of methods of efficiency in hospitals will be greatly accelerated when our colleagues return from their now perilous duties to the quieter work of peace. They will, no doubt, carry with them the advantages derived from centralization and authority of organization and the old-fashioned, or former staff of a hospital, with the various lines of cleavage of opinion, will be subordinated to the newer spirit of discipline acquired on the battlefields and transferred with all its merits to our civil institutions.

TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting, held December 12, 1918

The Second Vice-President, DR. HARRY C. DEAVER, in the Chair

CHARCOT KNEES COMPLICATED BY FRACTURED LEG

DR. JOHN B. ROBERTS presented a man with Charcot knee-joints who had been under treatment for lues by Dr. B. A. Thomas at the Polyclinic Hospital prior to and subsequent to coming under Doctor Roberts's care for syphilitic fracture of the tibia and fibula of the right leg just above the ankle. This occurred about two years ago while the man was walking in the street. No undue force had been applied to the bones which simply gave way under him as he walked. There seemed to be nothing special in the X-ray appearances to suggest a bone dyscrasia. Doctor Roberts treated the fracture in a swung fracture box in the usual manner. Union took place and the man was discharged with what appeared to be a well-united fracture of the tibia and fibula. It was the opinion of Doctor Roberts at that time that the fracture was not due to syphilitic bone softening and the man was expected to have no further difficulty if he postponed weight bearing for the usual period after fractures at the ankle. A number of months afterward he came under Doctor Roberts's observation again and said that he had been walking without any special support to the fractured bones. The leg showed a large mass of bone and callus at the ankle with lateral and backward displacement at the seat of fracture. The appearances still exist but he has been wearing now a brace to prevent further deformity and disability. The Charcot knees are characteristic and the man has been under constant treatment for about four years, taking large amounts of potassium iodide and mercury and many injections of salvarsan and arsenobenzol. The long-continued treatment with the support given by the orthopædic surgeons to his knee-joints and to his fractured leg has brought this man to a condition which enables him to make a living, though when first seen by Doctor Thomas he could scarcely move the limbs which were supposed to be the seat of paralysis of doubtful origin. The man's indomitable courage and the wisdom of Doctor Thomas, his first attendant, have reconstructed his legs to an extraordinary extent.

ERRONEOUS INTERPRETATION OF X-RAY PLATES

DR. JOHN B. ROBERTS showed a boy who had sustained a fracture of the lower end of the humerus which under ether was determined to be a fracture

or diastasis of the external condyle of the humerus without displacement. The X-ray seemed to show considerable displacement of the fragment at variance with what the clinical examination suggested. He also presented the X-ray plates of an old man who had had a dislocation of the right shoulder-joint of the subcoracoid variety. Dr. Morris Booth Miller and Doctor Roberts reduced the luxation under ether and felt sure from the anatomical appearances and the surgical examination that the head of the humerus had been properly replaced. X-ray examination by a röntgenologist of experience was made. The report that came to the surgeon was that the bone was not completely replaced. The subsequent history of the case showed that reduction had been complete and the interpretation of the X-ray plate was erroneous. These cases are indications that the surgeon and the röntgenologist should work together in order to get the true meaning of X-ray results as shown in photographic plates. This statement, of course, corresponds exactly with what we all know is also necessary in pathological and surgical consultations; namely, that neither the surgeon nor the microscopist, nor the röntgenologist can depend entirely upon his own findings. Each special method of examination needs at times to be checked up and correlated with the clinical or pathological or radiological examination, as the case may be.

POST-OPERATIVE INFECTIONS OF THE PAROTID GLAND

DR. JOHN B. DEEVER read a paper with the above title for which see page 128.

DR. MOSES BEHREND said that two months ago he operated on a case, removing the gall-bladder and the appendix. Two days later the parotid gland on one side became inflamed. The following day the gland on the opposite side was affected. The pain was intense and both glands had to be incised. The man had double facial paralysis which, however, entirely disappeared. He believed the paralysis was due not to the incisions but to the enormous pressure upon the facial nerves. The man had complete control of lips, corners of mouth and cheeks before he left the hospital. The case seemed of special interest because both sides became involved. In one other case following a minor operation the man developed an infection and later a severe parotitis. Numerous incisions were necessary to get rid of all the pockets of pus, the patient making a complete recovery without facial paralysis.

DR. J. TORRANCE RUGH remarked that the mouth presents the most profuse bacterial flora of almost any of the cavities of the whole body. If mucin acts to limit the development of bacteria, why then should there be such great number and variety of bacteria in the mouth?

DOCTOR DEEVER, in closing, said that the case to which Doctor Behrend refers he saw. The source of the infection in that case was probably the tonsils. The patient had a cardiac lesion. There was an acute infection of the parotid gland with deep suppuration. An incision was made into the gland

by Doctor Behrend. Doctor Deaver regarded this case as an instance of hæmatogenous infection. He frequently had this type of infection in suppurative appendicitis and other infectious conditions. He had seen abscess of the pancreas result from infection elsewhere in the abdomen.

RENAL CALCULI

DR. F. A. MANTZ (by invitation) read a paper with the above title. He said: The predisposing causes of renal calculi are sedentary habits, high living, and poor hygienic surroundings. The formation of these calculi is dependent upon the condition of the excreted urine, rather than upon an inflammatory process of the renal mucosa. However, there are exceptional cases; as pyelitis has been followed by extensive and massive stone formation in the kidney.

In order that these concretions may form, there must be of necessity an excess of certain of the solid constituents of the urine, which are most frequently urates, phosphates and oxalates. An excess of any of these salts favors a coagulation necrosis of the renal cells, thus forming a good nucleus for the deposit of any of the excessive salts that are present.

The symptoms depend more upon the position of the calculus than upon its size or shape. A calculus in the parenchyma or in a calyx, not infected and non-motile, may give rise to no symptoms at all. This fact has been proved by the X-ray examinations of patients suffering with other conditions than renal calculi, the calculi present being discovered accidentally in this way. The principal symptom is pain, radiating in a line to the bladder, scrotum and meatus, together with a desire to micturate. The urinalysis reveals red and white blood cells, pus and hyaline casts. Anuria is a symptom of bilateral lesions, but may be present when the lesion is unilateral, and is then caused by reflex action upon the other kidney.

To establish a positive diagnosis and to determine the proper treatment, we must call to our aid the cystoscope and the X-ray. The cystoscope reveals alterations in the flow of the urine from the ureter of the affected side; and catheterization of the ureters and examination of the two urines separately with the use of the phthalein test will determine whether or not the other kidney functionates sufficiently to carry on the necessary renal elimination, in case a nephrectomy is deemed expedient. Likewise, a wax-tipped ureteral catheter, as employed by Dr. H. A. Kelly, may be passed, to corroborate the presence of a suspected calculus when the X-rays fail to show a shadow. The X-ray examinations must be entrusted to the most experienced röntgenologist available—one who is able to interpret properly the skiagram and to differentiate the different shadows; since the uric acid and phosphatic calculi hardly cast any shadow, while the oxalate *stones* cast a strong shadow. The röntgenologist is often able definitely to locate the calculus, and thus facilitate its removal.

Having definitely diagnosed the presence of a renal calculus, its size and location, and whether the lesion is unilateral or bilateral, we must further

analyze the patient's physical condition, so as to determine the safest and best method of effecting *the desired cure*. The principles of renal-calculi surgery are to-day so scientifically sane and sound that, by adhering to them, the mortality due to these operations may be kept very low. By making such a thorough analysis of the case, we can nearly always determine before operation whether a nephrolithotomy is required, or a pyelotomy or a nephrectomy.

We should do a nephrolithotomy only when it is utterly impossible to remove the calculus by doing a pyelotomy. As a rule, all renal calculi are friable and easily crushed. Hence, most of the larger stones that fill the renal pelvis and calices may be crushed with an ordinary Kocher hæmostat or other forceps, and removed piece-meal, by way of the pyelotomy. Afterwards, the cavity should be thoroughly flushed with a normal saline solution or a mild antiseptic, to wash out the small remaining fragments or sand.

The risk of having a severe secondary hemorrhage following a nephrolithotomy far overbalances the probability of a permanent urinary fistula as the result of a pyelotomy. These secondary hemorrhages, which usually occur from the eighth to the tenth day after a nephrolithotomy, are always severe, and constitute a great source of annoyance and embarrassment to the surgeon who is fearful of being obliged to do a nephrectomy, which would have very serious consequences in a case in which the other kidney did not functionate sufficiently to carry on the required elimination.

A nephrectomy should be attempted only when there are many stones within the kidney, or when there is one large stone with an associated infection and destruction of the parenchyma.

The nonoperative cases include those in which a renal calculus is found in an extensive X-ray examination for some other condition, and in which the stone gives rise to no symptoms; especially so, when the patient is a poor surgical risk. On the other hand, all cases with an associated complication, such as extensive pyelitis, hydronephrosis or anuria, should be operated upon as soon as possible, even though the risk may be great; also cases in which the calculus has passed from the renal pelvis into the ureter and has there remained lodged, if, within a reasonable time, it does not find its way into the bladder. A calculus within the renal pelvis or in the parenchyma, giving rise to the symptoms of renal calculi, in a patient who is a good surgical risk, should be removed immediately, to avoid possible complications and sequelæ.

There is no drug that will dissolve a renal calculus within the human body. However, it is essential to treat the patient systematically after the operation, in order to prevent further stone formation. Diluents, such as distilled water in large quantities, to dilute the solid constituents of the urine, should be given; and a limited diet should be employed. No red meats should be allowed; but cereals and vegetables of all kinds, except rhubarb, tomatoes, asparagus and strawberries. Sugars, malt liquors and wines are interdicted, especially in the cases of those patients who are of a gouty diathesis. The free use of saline purgatives is imperative.

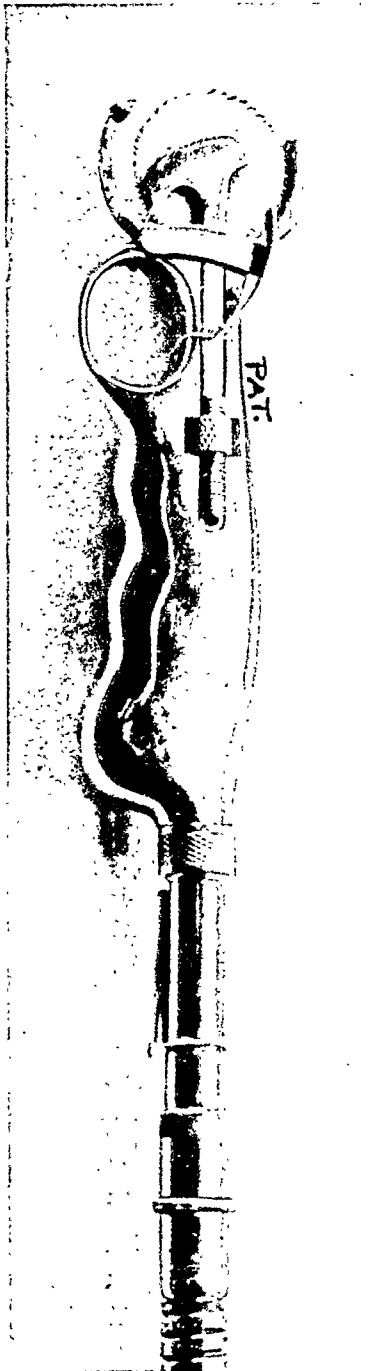


FIG. 1.

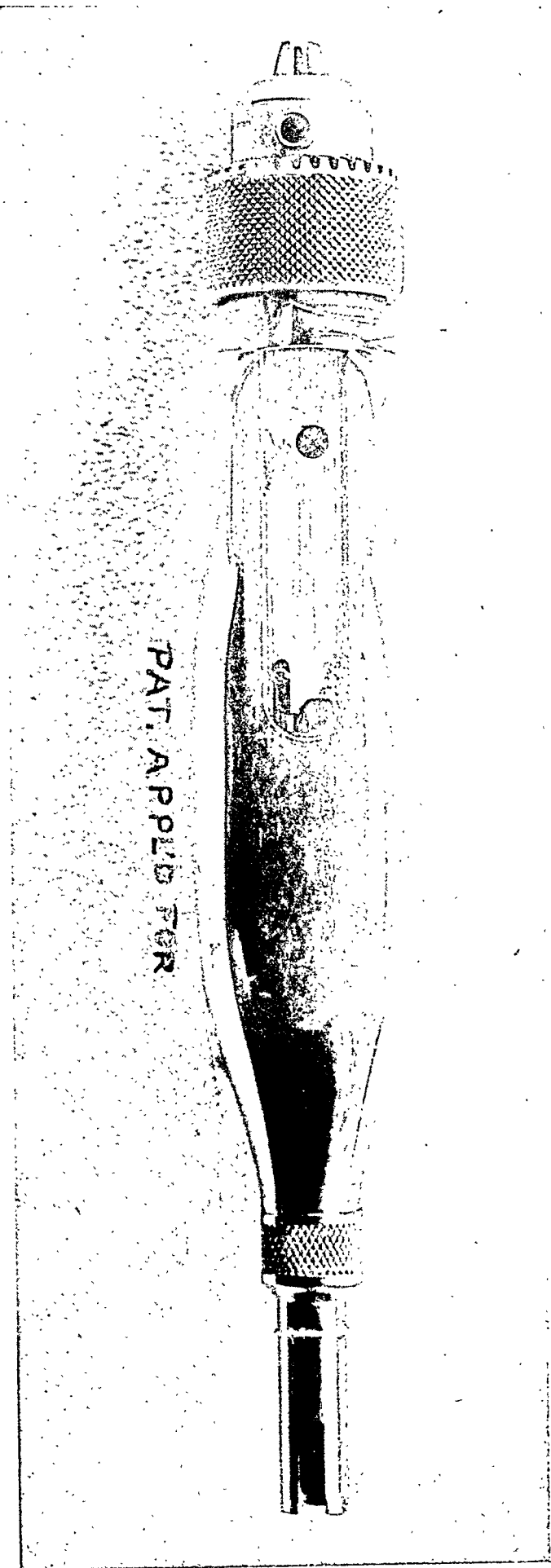


FIG. 2.—The tool-holder.

NEW BONE SAW EQUIPMENT

Post-operative anuria is reflexly caused by the rough handling of the kidney and the effect of the anæsthetic. Personally, however, I believe that this complication can, in a great measure, be prevented by giving the patient large amounts of distilled water with potassium citrate, a few days before the operation, in order to render the urine bland and stimulate its flow. Morphine sulphate, one-quarter to three-eighths of a grain, with 1/150 of a grain of atropine sulphate, should be administered half an hour prior to operating, for its anoci-association effect; but no morphine or atropine should be given after the operation.

Following the surgical procedure, normal saline solution as per the Murphy drip, should be administered, and plenty of water by mouth, as soon as the patient is able to retain it. Occasionally, also a mild diuretic may be given. These remedies constitute about all the medication necessary after the operation.

DR. JOHN B. DEAVER said with reference to the passage of stones that failed to show a shadow, to which Doctor Mantz had called attention: They are difficult cases, and he recalled a number. One case seen recently was that of a man from the South. He had the symptoms of bloody urine, renal colic, pain, etc. He was referred to the röntgenologist. The report came back that the man did not have a stone, but that there was a tubercular area in the kidney. Another good röntgenologist said that the X-ray examination of the kidney was negative. The man was then cystoscoped and the operator said he did not know what the man had but that the blood all came from one kidney. Doctor Deaver made an exploratory exposure of the kidney and the result was the finding of a stone one-third the size of the fist in the kidney. He then called up the first röntgenologist who said he would like to have the stone. He put it in water and could not get a shadow. The case was one of those impossible of diagnosis because of the quality of the stone. No doubt there occur many such cases which slip through our hands.

NEW BONE SAW EQUIPMENT

DR. H. C. MASLAND (by invitation) demonstrated the new bone saw equipment devised by him. It consists of two major instruments quickly adjustable to a flexible shaft of ample strength, driven by an electric motor.

One instrument is a circular saw mounted in a very convenient handle. The saw has a gauge immediately adjustable to cut any depth desired. This can be drawn back and an inside guard attached which protects the dura in cutting the skull or any other underlying soft tissue when the saw is used elsewhere. The nose of the instrument is about one inch wide, so that the saw can be used on deep-lying bones for either a vertical or a bevel cut.

The other instrument is a universal tool holder having a construction to facilitate the performance of various other operative procedures. Drills from the size of catgut up. Burrs of various types and sizes, a special trephine for opening the skull safely, hollow mills for bone pins, side cutting

mills to make level floored gutters for inlay work, a small circular saw, taps for threading holes and dies for bone pins.

This tool may be power driven or immediately detached and used as a hand instrument.

The doctor drives his instruments at low speed and thereby eliminates burning and does not need the water drip. The equipment meets rigid aseptic requirements.

DR. J. TORRANCE RUGH said that he had always felt that the difficulty in this type of operating device was in the cable, and this problem Doctor Masland seems to have solved. The majority of these cable-operated machines keep jamming and bending, but Doctor Masland has a cable which is powerful enough to drive the instrument evenly. It has the advantage also of being of a size convenient to handle in the field of operation. Doctor Masland tells us that the cable may be boiled, but it must have oil, and the speaker would feel a little doubtful about boiling it. He suggested a device such as may be used on the Albee machine. For the supply cord there is a long tube or muslin casing running up to the handle of the motor. Some have a motor of the same type as Doctor Masland's and wrap the whole thing in a sterilized casing when using it and have no trouble about asepsis.

Another feature which commends this machine is that it is a low speed motor. He had never felt favorably inclined toward a high speed motor in bone work. It will burn the bone unless water is used, and many other inconveniences attend its employment which are eliminated by the low speed machine.

DR. MOSES BEHREND said that with the Albee instrument one must hold a rather heavy motor; but with this the toolholder of Doctor Masland can be held with one hand. The Albee motor will often jam, as has been said. Doctor Masland's does not do this on account of his slow speed motor. The chuck is almost perfect; it will hold a hair. The smallest kind of a drill can be used which is a distinct advantage. Also the chuck is commendable because one can put in almost any sized instrument.

DOCTOR MASLAND, in closing, said that his first sleeve was of the usual dental composition type, covered with a sterilizable muslin sleeve. This did not appeal to him as thorough asepsis. His present cable and tubing are metal throughout, save for the asbestos packing in the crease of the spiral of the tubing to make it water-tight. The sleeve is brass, nickel-plated, and of the same construction as gas or speedometer tubing. A little heavy grease is used for lubrication. This will not run out through the accurately fitted ends. If it did it could be prevented by elevating the ends of the flexible shaft in the sterilizer.

THE SEGMENT TREPHINE

DR. JOHN B. ROBERTS remarked upon the evident efficiency of this saw of Doctor Masland. Those who have worked in bone surgery of the skull have realized the trouble with ordinary saws and trephines. Years ago he



FIG. 4.—Roberts's cranial trephine, made in 1882, to be driven with Bonwill dental engine.

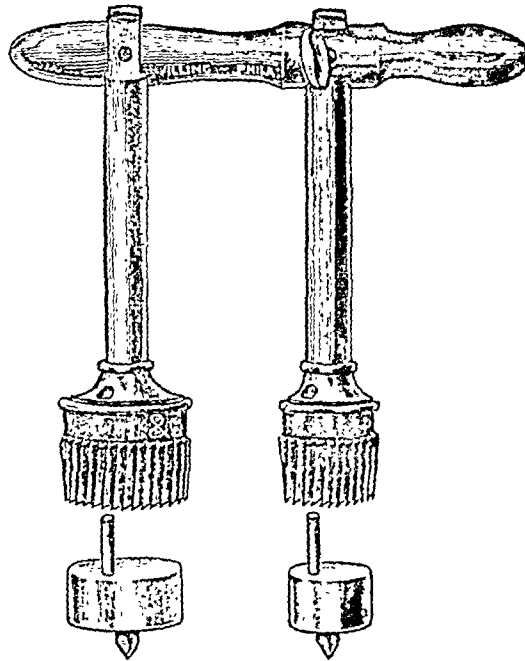


FIG. 5.—Roberts's aseptic trephine, late model.

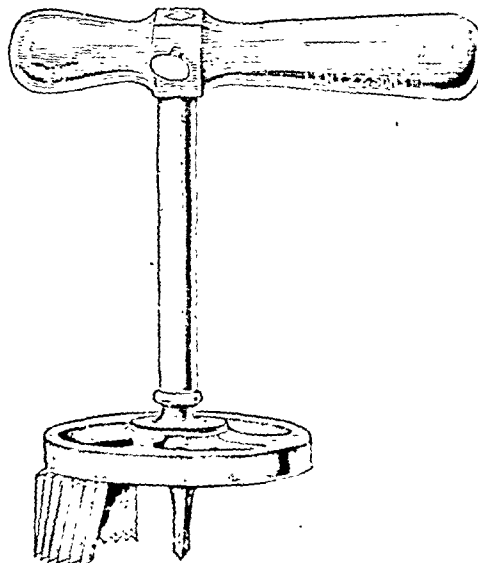


FIG. 6.—Roberts's aseptic segment trephine for making trefoil-shape flaps of bone in resecting the cranium.

undertook to use the Bonwill surgical engine for driving burrs for bone work on the extremities and head, but found it difficult to keep in order in surgical operating rooms. The little cranial trephine, which Doctor Masland has adopted to use with his outfit, Doctor Roberts had made for cranial use about thirty-five years ago, when he demonstrated that one could safely trephine the cranium by boring holes with a flat fissure burr. An entrance could thus be made into the cranium without damaging the dura. This little trephine (Fig. 4) with its conical shape and spiral cutting surface has a way of jamming itself when the saw edge of the crown cuts through the bone to the dural surface. Doctor Masland's experimental work with him, in the laboratory and on patients with his new saw, has revived the use of this instrument. The electric motor and cable which Doctor Masland uses in connection with his saw drives the trephine very satisfactorily. The instrument is easily sterilized and has a small hole through which it may be cleaned and the button of bone pushed out if it remains caught within the trephine. It needs no centre pin, or a drain with a centering point, though the latter could be fitted to it. Through small holes made by this instrument the Gigli saw may be used, if the Masland saw is not at hand, to make the osteoplastic flap to be turned down for access to the brain surface. Some years ago Doctor Roberts devised an aseptic trephine without the old-fashioned centre pin, which is familiar to many of the Fellows. He now showed a new model (Fig. 5) recently made for the army by Pilling. It is in some respects not as satisfactory as the original made by hand at the time when surgeons began to do operations for the removal of brain tumors, twenty or more year ago, but large numbers of the present form can be made by machinery and therefore at a much lower price. It does not need the stem which the instrument maker has put upon the drum which carries the centre pin. He also showed (Fig. 6) the aseptic segment trephine which does well in making clover-shaped flaps in resection of the skull for entrance to the cranial cavity when special saws like the Masland saw are not at hand. It and the various methods used to do osteoplastic sections are valuable now that surgeons always try to have bony closure of the gap made in the cranial wall. The methods which depend upon cutting away with gnawing forceps the bone and leaving great openings to be closed only by fibrous tissue have become antiquated and are to some extent looked upon as survivals of pre-Listerian surgery.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

Stated meeting, held December 11, 1918

The President, DR. CHARLES H. PECK, in the Chair
RESECTION OF SUPERIOR MAXILLA

DR. WINFIELD S. SCHLEY presented four patients who had been subjected to operation for cancer of the superior maxilla. The first was a man, forty-seven years of age. Six months before admission to hospital left naris became entirely occluded. He was told he had a nasal polyp, which was partially removed without benefit. Later removed again by his physician and submitted to microscopic examination. Pronounced sarcoma. When seen left nostril tightly blocked and cheek bulged perceptibly. At operation the antrum was completely filled with tumor and the left naris up to the ethmoid. Tumor proved to be a giant-celled sarcoma. A very complete excision was done.

Patient presented to show condition after three years and the simple prosthetic apparatus with teeth that the dentist has made. His speech is practically normal, as is mastication.

The second patient was a man, fifty-three years of age. Four years before admission he had the first nasal polyp removed. For over three years the left naris has been more or less occluded. Three months ago he was operated for polyp of left naris. Rapid recurrence. Another removal with microscopic examination showed "simple polyp." When first seen the left nostril was almost completely blocked and cheek bulging had begun. A specimen taken at a deeper level showed squamous-celled epithelioma. At operation extensive disease of left side of naris and whole of antrum existed. An extensive resection was done. He was now presented to show extent of epithelial growth and repair after three months and to illustrate again the danger of mistaking deep-seated malignancy for simple nasal polyp.

The third patient was a woman, forty-seven years of age, who twelve years ago first noticed a small mass upon the gum of the upper jaw opposite the canine tooth and apparently attached to the bone. In the ten succeeding years eight or nine local operations were done. When first seen she presented marked tumefaction of the right cheek under scars of previous operations. At operation the tumor tissue was found filling the antrum, the anterior wall of which had been removed at a previous session. A complete local excision of tumor (giant-celled sarcoma) was done and the antrum and tumor area strongly radiumized. No sign of recurrence after a year and eight months.

RESECTION OF SUPERIOR MAXILLA

This patient presented to show a low type of malignancy probably starting as a giant-celled epulis.

Lastly was presented a patient with a much neglected case of squamous-celled cancer of the left upper jaw that had crossed the midline of the hard palate. A two-stage operation was done. Glands of neck and whole of jaw of affected side and later hard palate of opposite side. Ultimate recovery doubtful. Case presented to show importance of neck dissection in carcinoma of upper jaw. *Her lymphatic involvement in the neck was upon the opposite side to the primary and major growth.*

DR. ADRIAN V. S. LAMBERT presented a woman, sixty-five years old, who was admitted to the Presbyterian Hospital, on June 7, 1915, with the history that three months prior to admission she noticed a swelling along the inner side of the gum on the left side of upper jaw. At first this grew very slowly, if at all, but during the past month it had increased rapidly in size and had extended backward along the roof of the mouth. She had no pain or discomfort except that due to her inability to wear her plate, in consequence of which she believed she has lost ten pounds.

On admission her physical examination showed a fairly well-nourished woman apparently suffering no pain. She had a diastolic murmur over the third left intercostal space near the border of the sternum. On the left side of the roof of the mouth there was a tumor mass extending from the alveolar margin behind the anterior arch backward to the posterior border of hard palate. This mass also extended a trifle beyond the median line. It was irregular in contour, having a rounded prominence near the alveolar margin and a large crater-like ulcer near the median cavity. The antrum seemed to be free of any involvement. No cervical lymphatic glands could be palpated. The skin of the face did not appear to be involved anywhere. A section of the mass was taken a week prior to operation and was reported "epithelioma of roof of mouth." The buccal cavity was kept clean for a week prior to operation. This was done with mouth washes and irrigation.

On June 14, 1915, a partial removal of the maxilla was done. The external carotid was ligated as a preliminary step just prior to the removal of the main mass. The Weber incision was used. This gave an excellent exposure. The floor of the orbit was removed together with the infra-orbital margin, and the incision passed to the right of median line along the hard palate. The maxilla was removed except a portion of its nasal process. The soft palate was not removed. She made a good post-operative recovery and left the hospital on the eleventh day post-operative.

She was seen in the follow-up clinic on July 18th, one month after her operation. She reported everything as progressing well. She was seen again on August 22nd, and several subcutaneous nodules in the scar at the angle of the eye and nose were noted. A positive diagnosis of recurrence was not made at this time. She was seen again on October 26th when she had a well-marked recurrence on the nasal process of superior maxilla. This was a hard nodule, reddened with skin glazed over it about 2 cm. in

diameter. It is very hard and shows a slight ulceration on the summit and is firmly adherent to the deeper parts.

She was operated on a second time October 28, 1915. The growth and an area of skin 1 cm. wide from its margin were removed. The inner canthus of the eye was preserved. The nasal process of superior maxilla was not removed but was bared of periosteum. A flap was then taken from the centre of the forehead to fill in the defect and was swung about a pedicle having its blood supply from the frontal artery of right side of nose. This was sutured into the defect. The post-operative course was uneventful except for slight infection at lower edge of flap, and she left the hospital on the eleventh day post-operative.

She has been seen in the follow-up clinic every six months and had not been willing to have any plastic on the redundant flap. The sinus at inner angle was not noticed in June, 1918, and has appeared only lately.

HYDRONEPHROSIS CURED BY PLASTIC OPERATION

DR. HERMANN FISCHER presented a man, thirty-two years of age, who for three years had been suffering from attacks of pain on the left side of his abdomen.

The pain starts in the lumbar region and radiates towards the abdomen. The attacks occur at irregular intervals and in the last three weeks he had five such attacks. The pain is almost unbearable and is accompanied by nausea and vomiting. In between the attacks he feels quite well.

On examination in the height of an attack there was found a tumor the size of a child's head, in the region of the left kidney. It moved downward with respiration, was globular and smooth in outline, and had a cystic feel. A few days later, the tumor was much smaller, although still easily to be felt. His pain, however, had left him and he felt much better.

On entering the hospital on August 30th, he had another attack of pain and on examination the tumor was again as large as at the first examination.

X-Ray.—Shows an enlargement of left kidney, but no stone.

Cystoscope showed normal bladder; right ureter opening normal, easily entered by catheter; left ureteral opening much smaller, cannot be entered by smallest catheter at hand. Urine from right side normal. Phenolphthalin, 54 per cent.

Diagnosis.—Left hydronephrosis.

Operation.—September. Bergmann incision. Large hydronephrosis was found with almost normal kidney. There were no anomalies of arteries. The ureter close to the pelvis was narrowed, but no outward signs of inflammation around ureter could be ascertained. The ureter was inserted very high into the pelvis.

As there was no indication for removal of the kidney, a plastic operation was decided upon.

The pelvis of the kidney was opened by a longitudinal incision near the insertion of the ureter. The spur that was formed by the insertion of the

WOUND TREATMENT WITH CHINOSOL AND SALT

ureter and the distended pelvis below the insertion of the ureter was also incised longitudinally and sewed together transversely. In this fashion the spur was obliterated and the uretero-pelvic junction placed at the lowest point of the pelvis. By excision of an elliptical piece, the pelvis was narrowed.

Suture of pelvic incision by fine catgut; small cigarette drain was led down behind the kidney, and the wound closed up to the drain.

A pelvic fistula developed after removal of tampon on the tenth day; this, however, closed after two weeks.

The wound is now healed and he is free from pain. It is very difficult to account for the condition presented by this man. Tuffier was the first one to call attention to strictures of the ureter which were produced by inflammatory conditions, mostly gonorrhœa. The reporter thought that the pouching out of the pelvis of the kidney was secondary and not primary; it is caused by the pressure of the retained fluid. The moving of the ureter upward is also secondary, brought about by the sagging of the lower pole of the large hydronephrotic sac. It is difficult to see how a cure can be effected by simply diminishing the size of the sac by sutures. If there is an infection present he doubted whether a plastic was desirable.

DR. CHARLES H. PECK stated that many of these cases are due to high implantation of the ureter and valvular obstruction. He had tried the operation that Doctor Fischer describes once without success. A number of cases were treated by resection of a portion of the redundant or hooded pelvis. For a number of years it has been his practice to pass a ureteral catheter from the nephrotomy wound down the ureter to the bladder and leave it in place for a few days, to prevent kinking or obstruction of the ureter while the kidney was becoming fixed in its new position. By this method many kidneys with early hydronephroses may be saved.

WOUND TREATMENT WITH CHINOSOL AND SALT

DR. WILLIAM C. LUSK presented the following seven patients: 1. Wound of tendons of wrist. 2. Empyema cavity. 3. Colon bacillus cellulitis. 4. Staphylococcus cellulitis. 5. Staphylococcus abscess of face. 6. Pelvic sinus. 7. Old wound laying open entire ischio-rectal fossa, in the treatment of each of whom chinosol and salt had been used. Notes on these cases will be included in an original article which is to be published shortly.

DR. ROBERT T. MORRIS stated that his results had been practically like those of Doctor Lusk in the use of chinosol. Until he had taken up the Carrel-Dakin method for treatment of wounds chinosol solution used in the strength of bichloride solutions had been his main dependence as an antiseptic. He had not used it with the salt nor in the strength quoted by Doctor Lusk. Chinosol solution made an excellent hand preparation, particularly when one had to do a series of operations in succession. It made an excellent non-toxic immersion bath for infection of the extremities.

"THE OPERATIVE TREATMENT OF CANCER OF THE SUPERIOR
MAXILLA"

DR. WINFIELD S. SCHLEY read a paper with the above title.

DR. ROBERT T. MORRIS stated that it seemed to him that preliminary ligation of the carotid was of advantage in operations for the removal of the superior maxilla for two reasons. There was less blood in the field while the surgeon was at work, and furthermore, the principle of starving the neoplasm appeared to have some evidence in its favor. Change in the rate of blood determination to a locality appeared to have special influence upon morbid cell construction. Sometimes when he had removed lymph-glands from the neck which appeared not to be enlarged little nests of epithelium had been found in cases of carcinoma involving the superior maxilla. The speaker had used paraffin injection for permanent elevation of the orbital structures after the orbital plate had been removed.

DR. ADRIAN V. S. LAMBERT said that in the few cases of upper jaw removal that he had done he had only tied the external carotid and obtained a very satisfactory hæmostasis. He was surprised to hear mentioned the ligation of the common carotid in the same class as that of the external. He had only ligated the common carotid once and that was not very successful. It is a very serious surgical procedure, while the ligation of the external carotid, as Doctor Schley has shown, is attended with hardly any fatalities.

DR. HERMANN FISCHER said that before the days of general anæsthesia the mortality after resection of the superior maxillary bone was low; when general anæsthesia was introduced the mortality rate increased on account of the frequency of post-operative pneumonia. He usually operated having the patient in a half sitting position under morphine-ether narcosis. The patient must not be deeply narcotised, pharyngeal reflex not abolished, so that he is still able to swallow. Laryngeal insufflation is also a very satisfactory method of narcotising these patients. By these means post-operative pneumonia can be avoided. He always does the operation in two stages, first ligating the external carotid artery and removing all the lymph-glands *en bloc*, from the omohyoid gland upward. Two or three days later resection of superior maxillary bone. He always removes the glands on the side of the lesion, whether they can be felt enlarged or not. He thought this was a very important point.

DR. CHARLES H. PECK stated that intratracheal anæsthesia was very useful in cases of this type. The first case in which he had ever used it was in resection of the superior maxilla and ethmoid for sarcoma. The method prevents aspiration of blood and mucus into the trachea. Intra-pharyngeal anæsthesia does not answer the same purposes because it does not guard against this danger.

DR. W. S. SCHLEY in closing remarked as to the use of intratracheal anæsthesia, that with the lower jaw it is more necessary than in operations upon the upper as it is more difficult to keep blood out of the pharynx. With

external carotid ligation in upper jaw operations the bleeding is small and little or none of it passes the nasal tubes with light gauze packing at the back of the pharynx. The packing does not interfere with the breathing and the field of operation is so wide open that one has very little difficulty in controlling any moderate hemorrhage that occurs.

In the early history of this operation there was a large mortality from sepsis, from hemorrhage and pneumonia. We have practically eliminated the first two and pneumonia is no more frequent than after any operation.

The speaker thinks intratracheal anæsthesia is perfectly feasible here, his preference, however, as said, has been the nasal tubes with the pharynx packed; and it works apparently very well.

The two-stage operation is good. He would rather not do carotid ligation more than two days before the jaw operation as the anastomotic connection is sometimes very quickly established. He would rather do it at the same time as it consumes but five or ten additional minutes. If the external carotid is ligated well above the bifurcation, at or above the superior thyroid, the mortality from embolus is practically *nil*.

So far in the cases he has done there has been no operative mortality, and all have had extensive operations, even in three stages if necessary. There are a great many more cures than recorded so far.

EDITORIAL COMMENT

GORDON HOLMES ON THE TREATMENT OF SECONDARY AND LATE COMPLICATIONS OF BRAIN WOUNDS*

At the Interallied Surgical Conference of November, 1917, Mr. GORDON HOLMES presented a report based upon the examination of 2357 patients who had been admitted into the hospitals of the United Kingdom for gunshot wounds of the cranium, affecting the brain directly or indirectly. In a certain number of these the wounds were of recent date, the others had not yet recovered from the immediate effects of their wounds at the time when the last medical reports as to their condition had been made, but there remained about 1567 cases in which it was possible to study secondary complications. All these cases dated back to at least three months before, and many have been followed for two or three years after their wounds. The clinical reports upon these patients have been obtained from different sources. In most cases they were derived from examination of the hospital records collected by the Committee on Statistics and Medical Research of the military and civil hospitals of the United Kingdom. As to a considerable number of men more seriously injured, the information was obtained from the reports of the Minister of Pensions. Five hundred and twenty-six cases were observed by the author personally during the first periods of their wounds in the hospitals in France, and their later condition he had followed since. These are included in this list.

The research has been limited to those wounded in the years 1914 and 1915, so that a sufficient period had elapsed for the evolution of later complications to have taken place. As the first surgical treatment of wounds of the brain has certainly been improved during these last two years, it may be hoped that secondary complications will be less and less common, much less than has been the case in the patients who are the subject of this present report.

Abscess of the Brain.—After healing of the wound, 37 cases of secondary abscess have been observed. In 28 instances these abscesses supervened between the third and sixth month after the wound; 4 between the sixth and seventh month; 3 between the eighth and ninth month; 1 during the tenth month; and 1 only after that period, namely, in the eighteenth month. It appears then that abscesses are more rare six months after the wound.

They have been observed in all types of penetrating wounds of the brain, but late complications were not met with in cases in which the dura mater had not been lacerated by the projectile or opened by the surgeon.

In most cases abscesses have developed directly at the level of the cranial

* *Comptes-Rendus de la Conférence chirurgicale interalliée pour l'étude des plaies de guerre*, 3e session, 5-8 Novembre, 1917.

wall and in many cases in the brain substance which had herniated. In cases of many wounded, however, they had formed at some distance from the original wound, either deeply in the hemisphere or in some distant region of the brain not touched by the primary wound.

They developed very frequently around bony sequestra which had not been taken away at the first operation, or under a necrosed fragment of the cranium. In a small proportion of cases they had developed around foreign bodies retained within the cranium.

Abscesses seem to develop with especial frequency as a secondary complication of wounds which had involved the orbit or the ethmoid region; in fact, in a large proportion of these which developed later, the infection was secondary to a sinusitis, or osteitis or to necrosis of a sinus wall. The development of an abscess was announced generally by headaches, vomiting, œdema of the papillæ and slowing of the pulse, and by the usual signs of increased intracranial pressure. Nevertheless, the absence of œdema of the papillæ was frequently noted, and in many cases drowsiness and lethargy, with an increase of local symptoms, were more pronounced than headache and vomiting. A slow pulse was sometimes the most significant indication of a rapidly increasing abscess. However, in many cases the abscess did not manifest any sign which revealed its presence. One man, for example, who had been excused from all work, fell suddenly one night in a theatre and died after a few hours. Postmortem revealed a large abscess in the frontal lobe at a considerable distance from the initial wound.

Operative intervention was resorted to in most of the cases, but the results were not satisfactory. Out of 37 cases, 28 terminated fatally, 9 of them immediately after operation. In other cases death was due to meningitis, to rupture of the abscess into the ventricle or to a progressive encephalitis; in certain non-operative cases the results of intracranial pressure. The best method of treatment has consisted in puncture or evacuation of the abscess by a small incision followed by drainage. Infection appeared to be less virulent when the abscess developed as a late secondary complication.

Meningitis.—While primary meningitis is the most serious complication and the most frequent cause of death in the first period of brain wounds, it is relatively rare in the later course of such wounds. It is, however, a common consequence of intracranial abscess when such abscess has not been operated upon in time, or when the operation is followed by shock. In many cases the meningitis was the result of rupture of an abscess, or extension of the infection to the ventricles. In the greater proportion of the cases of meningitis which survive to the late stages of evolution following gunshot wounds in the head, the infection originated in infected sinuses or in necrosed bones of the orbit, or in the ethmoidal region. In two cases of primary meningitis cure was obtained in both, the diagnosis was confirmed by lumbar puncture and both were treated by the repeated removal of large quantities of purulent cerebrospinal fluid.

Encephalitis.—The sudden appearance of acute symptoms, or the exac-

erbaration of existing symptoms, has been attributed in many cases to an encephalitis, but in the absence of anatomic-pathologic examinations, it is difficult to say whether this diagnosis was exact or not. However, there is no doubt that general symptoms, such as headache, and vomiting, associated with the appearance of the evident increase of local cerebral troubles, supervene from time to time, which cannot in much probability be attributed to the formation of abscess, for they disappear generally with appropriate treatment and do not return. In three cases death was attributed to encephalitis, but autopsy was made only in one case. In this brain there was revealed a diffuse and inflammatory softening without any formation of pus at the deeper part of the original wound. In one of these cases there were foreign bodies in the brain.

The clinical distinction of encephalitis from abscess is evidently difficult and uncertain, as when encephalitis exists, the headache is less severe and less persistent, and the vomiting and neuritis less frequent.

By reason of the uncertainty of the diagnosis in most of the cases, it is difficult to determine as to the best treatment of encephalitis. Frequently the symptoms give way after the extraction of bone or of foreign bodies situated superficially and accessible, which had been retained in the brain. Sometimes many patients healed rapidly after a simple exploratory operation, although neither pus nor foreign bodies were found. In other cases the symptoms disappeared with absolute rest and the application of ice to the head.

Infection of the Cerebral Ventricles.—The extension of the infection to the cerebral ventricles is one of the most serious complications of gunshot wounds of the cranium. They supervene often in cases in which cerebral hernia has developed with much loss of cranial substance. In such cases the lateral ventricle is generally dilated and forms a part of the hernial projection, and, if the latter is infected, or if septic encephalitis develops in the neighborhood, the infection extends to the walls of the ventricle and also to the cerebrospinal fluid. As a rule there results a generalized ependymitis, but sometimes the infected ventricle becomes shut off from the rest, and at post-mortem examination one finds it carpeted by a pyogenic membrane which contains purulent liquid. In some of these cases the infection appeared to have become localized and quiescent. The ventricles may also be infected by the rupture of an internal abscess. This invariably results in a generalized meningitis and death.

The surgical treatment of ventricle infection is not encouraging, but if one makes a diagnosis with some probability, it seems that in the cases of localized infection treatment might be attended with success. Among the 2357 cases of this statistic, there were 13 cases in which cure had followed rupture of the ventricle with an hernia, or by an operation practised for the purpose of evacuating a large quantity of cerebrospinal fluid. The greater number of the cases, however, with open ventricles died in a short time from meningitis or generalized ependymitis.

Cerebral Hernia.—As a rule, hernia is to be looked upon as an early complication of wounds of the cranium and of the brain, but as this hernia persists often for months, or may develop later, or as a consequence of the original wound of the cranium, or after secondary operation, it may also be considered as a late complication.

If one examine a large number of records as to the later course of head wounds, or if cases seen at the beginning were followed throughout their later course, one would see that the majority of cases which are accompanied earlier or later by large cerebral hernia have terminated more favorably than one would have thought. Out of 90 patients followed up, who had been the subject of large hernias and whose later course it had been possible to watch during a considerable period, 70 were completely cured and only 20 succumbed. Furthermore, the most of those who died owing to meningitis or to infection of a ventricle survived for the first two months after the wound. All these cases were operated upon very soon after being wounded.

The treatment of cerebral hernia varies in the different hospitals in England. Generally, simple aseptic or antiseptic dressings are applied and this is the method which has been the most successful. In other hospitals the application of astringent agents such as ninety per cent. alcohol or formol five per cent., or even in stronger solution, has been made use of. Surgical intervention properly so-called, has been almost uniformly unfavorable, but when the brain contains fragments of bone or splinters of projectiles, these should be taken away and the abscess or diffuse collections of pus should be opened and drained. In such operations it is important to limit the incision to the inflamed parts and to protect the other parts of the brain from infection.

At the beginning of the war a considerable number of hernias were resected in certain hospitals in England, but the results were disastrous, for the dilated ventricle was opened into frequently and meningitis and ependymitis resulted. Nearly half of the deaths are attributable to cerebral hernia in which the protruding brain substance was removed. The most striking cures followed contralateral decompression which relieves the tension of the hernia so much that the neighboring œdema lessens and permits better drainage.

Epilepsy.—Attacks of general and of Jacksonian epilepsy are very frequent in the earlier periods of cerebral wounds, but they persist in only a small proportion of cases. These disappear frequently after the escape of pus and the subsidence of inflammatory foci.

At the present moment it is impossible to estimate the frequency of epileptic attacks as later complications of wounds of the head, but certainly they appear to be present less frequently than one would have thought. They have generally been attributed to sequestra or to foreign bodies which produce around them an inflammatory reaction, but in most cases no foreign body is found in the brain. It is probably the cicatricial tissue which

develops about the wound of the cerebral substance which is the real cause of the attacks.

Epilepsy is observed after all kinds of head wounds. The brain was wounded directly in most of the cases which we have noted here and almost all these cases have been operated upon a little time after the wound; but attacks have been observed in other patients in whom there had been no appearance of fracture or of depression of the cranium, in which cases they appeared to be the result of cerebral commotion.

Post-traumatic surgical treatment of epilepsy is notoriously unsuccessful. When there are abscesses about foreign bodies in the brain, operations should be attempted, and this frequently prevents return of the crisis. Other surgical measures have not appeared to give any more satisfactory results.

Many cases may be relieved by the administration of bromides. It is the custom in some English hospitals to give moderate doses of the bromides to all men who are received with wounds of the head, and the administration is continued during the whole sojourn of such patients in the hospital. This treatment seems to be very efficient in lessening the frequency of the epileptic attacks.

Mental Troubles.—Slight mental troubles are very common as primary symptoms of gunshot wounds of the brain. Mental depression, slight irritability, forgetfulness, and even mild dementia may persist for long periods. The more grave mental troubles which demand treatment in special hospitals are very rare. Ten cases of such character have been noted from among the 2357 under examination. Two cases of transient mania from which the men rapidly recovered; in another, insanity with illusions was manifested, but was probably independent of the cerebral lesion. The others were depressed and melancholy or irritable, irresponsible and subject to acute attacks of excitability with illusions and hallucinations. Four among these recovered quickly. Such mental troubles were in most cases results of severe and extensive wounds, principally of the frontal lobes. Six of them had been operated upon immediately after having received their wounds; but the seventh, who suffered various obsessions, had only a small fracture which did not involve the brain or its membranes. This patient was also trephined.

Extensive Losses of Substance of the Cranial Wall.—A large proportion of the patients had large losses of the cranial wall as the result of wounds or of operation. Practically none of these, however, complained of symptoms which could be attributed to the breach of the cranial box. A large number of men who had had a ball in the head complained more or less constantly of a group of symptoms that our French colleagues have called the syndrome of the trephined ("le syndrome des trepannes"): headache, which may be general, but most often especially severe in the region of the wound, vertigo, amnesia, inability to concentrate the attention, and insomnia. These symptoms are observed, however, in all forms of cranial wounds and may be also notable and persistent after wounds only of the scalp or linear

EDITORIAL COMMENT

fractures of the cranium. Again, in cases with much loss of cranial substance they may be recognized as the result of simple exposure of the brain. Some of these patients, moreover, complain of attacks of dizziness and are prone to faint when they have raised or lowered their head suddenly in a rapid movement, but this symptom gradually passes away with time.

The principal inconvenience of loss of substance of the cranium is the danger of injury to which the unprotected brain is exposed. To remedy this danger plates or grafts of bone have been inserted in only eight of the cases included in the present statistic and in one of these it had to be taken out in consequence of the headache and suffering which it produced. The English surgeons prefer to substitute for such plastic agents a special external metallic protector, generally of aluminum, which is to be worn when there is any danger of receiving a stroke upon the head.

Secondary Effects of Splinters Retained in the Brain.—One hundred and sixty-four men having balls or fragments of shrapnel retained in the brain have been examined. All have been followed at least three months after the wound and 95 of them have been examined as late as two or three years after the wound. Twenty-three of the total number returned to active service in the army; 129 have been invalided, of whom the majority complained of the effects of their cerebral lesions, but 36 of these patients had taken up occupations in civil life; 12 had died, 8 of the 12 deaths supervened within six months after the wound. When the cases of mortality were analyzed, it was perceived that in the last 2 death had followed almost immediately the shock of operation undertaken for the purpose of removal of the splinters; in 3 it was attributable to abscesses which were not successfully treated. In 1 case, to meningitis, and in the others the causes of death were not determined.

The average mortality of these cases (7.3 per cent.) is noticeably greater than that for the total number of cases which were followed for more than three months after the wound (4.7 per cent.); but if it is considered that the splinters had made large tracks through the brain, that they were generally infected, the difference in percentage is much less than would have been expected.

As to the secondary complications, abscesses were the most important. They developed in six cases which is a proportion larger than that noted in the general statistic. Three of these patients died and three survived and healed after the evacuation of the pus and drainage. Some cases develop symptoms of encephalitis, as indicated by abnormal intracranial pressure generally associated with an increase or with the appearance of local symptoms. Some are operated upon without pus, or evident pus formation, being discovered. In some cases foreign bodies were removed, but whether that took place or not, the symptoms disappeared rapidly after the operation. In other cases the symptoms disappeared when the patients were subjected to complete rest, but only to reappear when normal life was resumed.

Nine of the 164 patients had had one or more epileptiform convulsive

attacks, but it is not yet possible to say whether the proportion of such cases is greater than it would be among men who had had penetrating wounds of the brain without a foreign body being retained. There is, however, no doubt that in the great majority of cases balls or fragments of shrapnel may remain in the brain without producing either accident or symptom, if they are not septic. In general, functional troubles are more rare than in those cases which are due to anatomical lesions produced by the wound itself, and not by the presence of the foreign body. Consequently, granted the dangers of operation when the fragments are deeply buried in the brain, one should not attempt to remove them unless there are symptoms of irritation or progressive disease.

GOSSET ON FUNCTIONAL RESULTS OF OPERATIONS UPON PERIPHERAL NERVES *

GREAT difficulties attend any effort to gather the final results of operations on the peripheral nerves. These difficulties are due to the long time required to obtain a cure and the dispersion of those who have been operated upon, which unfortunately has too often interfered with the proper continuity of the treatment. In future statistics it will be necessary to divide the cases into two quite distinct groups according as the operation upon the nerve trunk may have been practised late, after several months, or may have been done immediately after the wound, when a primary or secondary union of the wound had been practised. Data as to results which these immediate operations upon the nerves may give are unfortunately still rare, the operations having been too recent for the most part and above all since the records of the cases which have been subjected to operations upon the nerves in the hospitals at the front have not been sufficiently complete.

It is to be acknowledged also that the statistics which we have at the present moment, which have only to do with operations upon the nerves done late, involve large elements of error. The percentage of successes as reported is less than what it is really, for in a certain number of patients lost from sight and recorded as failures, it is probable that some after their departure from observation develop signs of nerve regeneration. The reporter had a very marked example of this fact. In visiting a fort in the neighborhood of Verdun he found in command there an officer upon whom he had done in March, 1916, a suture of the internal popliteal branch of the sciatic nerve for a loss of substance, 7 cm. in length. He here had the satisfaction of finding in this officer a complete restoration of all the movements in the area supplied by this internal popliteal nerve, except adduction of the tip of the foot. This regeneration had taken eight months to be accomplished. Now, this case which is a fine successful result of nerve suture had been marked upon his records as a failure, and it is by chance

* *Comptes-Rendus de la Conférence chirurgicale interalliée pour l'étude des plaies de guerre.* 3e Session, 5-8 Novembre, 1917.

only that he can register its ultimate fortunate result. In this case the wound had been sustained on the 7th of September, 1914, and the suture was done on the first of March, 1916, 18 months later.

The liability to record an operation as a failure is more frequent, since in a certain number of cases the favorable result does not begin to show itself until after two years or more. As, for example, in the case of a soldier who was wounded on the 4th of September, 1914, who was operated upon at la Salpêtrière on the second of December, 1914, there was complete division of the sciatic nerve with fibrous degeneration of the two ends; after wide refreshing of the two ends and suture, there was after a year no return of motility, but only signs of returning sensations since the 3rd of March, 1915. In December, 1915, good muscular tone was noted. In January, 1916, voluntary motility had returned in the triceps of the calf and in the posterior tibial; the patient walked much better, and in the beginning of 1917 the muscular power was improved and improvement was continuing. Here, then, was a case in which suture of the sciatic nerve showed no tendency to functional restoration at the end of nearly a year, in which after two years it had become noticeable and the improvement was continuing.

The data forming the basis of the present report the author has derived from replies sent by different neurological centres to a questionnaire which was addressed to them from the Service de Santé. These replies give the results of operations done upon 1340 nerve trunks.

Brachial plexus	54 cases	Sciatic nerve	135 cases
Median nerve	191 cases	Internal popliteal	42 cases
Radial nerve	436 cases	External popliteal	106 cases
Ulnar nerve	369 cases	Crural nerve	7 cases

The author had further inspected the records of 11,986 wounded men who had been invalided on account of lesion of the upper limb and 21,052 invalided for wound of the lower limb. He had also been able to avail himself of the personal records from the different services which he had personally directed from the beginning of the war, especially at la Salpêtrière and at Buffon, where had been done by himself and his assistants, and his colleagues, Chutro, Jean Berger, Pascalis and Charrier, exactly 671 operations upon peripheral nerves.

Finally, he had availed himself of a certain number of publications upon the special point of late results after operations upon the peripheral nerves for gunshot wounds.¹

In an attempt to appreciate the ultimate results of operations practised on peripheral nerves it is necessary to separately consider each nerve trunk, for the experience of this war has shown, in effect, that the operative results are not identical. For example, the case of the radial nerve is not that of the ulnar nerve. And for each nerve also it is necessary to specify the nature of the anatomical lesion and the operation which has been done.

¹ Wiart, Walther, Mauclair, Auvray, Duval, Tuffier, Mouchet, Benisty.

Therefore, there must be stated seriatim the results for the radial, the ulnar, the median, the musculocutaneous nerves of the arm, the brachial plexus, the internal popliteal and the external popliteal branches of the sciatic, the anterior tibial and the posterior tibial and the crural nerves. The purely sensory nerves also require separate consideration.

It is necessary further to take into account the time which had elapsed between the wound and the date of the operation and above all the time elapsed from the date of the operation to the moment when the patient has been seen again. Several months, five or six at least, are necessary in the most favorable cases to begin to appreciate the therapeutic results. For certain nerves, such as the sciatic trunk, it takes 15 to 18 months and even two years and more, to accomplish the progressive regeneration of the nerve and its functional restoration.

In statistics of operative results for each nerve it is necessary to take into account, also, the nature of the anatomical lesion and of the operation which has been done. From the point of view of the nature of the lesion, there should be considered (a) incomplete division; (b) complete division with fibrous continuity; (c) complete division without fibrous continuity. The results also should be checked up according to whether the operation was one of liberation, partial suture, complete suture after free resection, or graft.

In stating the results it is necessary to agree upon a terminology which will not involve confusion. The patients should be classified after the elimination of those who have been lost sight of, or who have been operated upon within six months, under the headings of *improvement*, *very great improvement*, and *cure*.

Under *improvement* may be classed those where there is a return of sensation or muscular tonicity, or a reappearance of some mobility, whether voluntary or under the stimulus of the faradic current. As *greatly improved* when voluntary movements have returned almost completely, whatever may be the condition of sensation and electrical reaction. As *cured*, when all the muscles have regained voluntary contraction, although there may still exist some defect of sensation and electric reaction.

To appreciate the return of voluntary movement of certain groups of muscles is not always easy unless observers are careful to eliminate certain causes of error and particularly supplementary movements which might make one think a complete functional restoration had taken place, when such movements were due to muscles innervated by other nerves. Surgeons cannot be too careful to guard against such errors into which they often fall.

One may properly employ the word *cure* only when the patient has the power to accomplish voluntarily certain simple movements which the neurologists have pointed out as requisite in order to guard against mistaking false restoration through supplementary means.

Thus, in his report to the Congress of Neurology, Professor Pitres, of Bordeaux, insisted upon this great cause of error and proposed to adopt a certain number of criterion signs so simple that their use might be available

to every practitioner, and so characteristic that their determination might be considered in each case in particular as a sufficient test to demonstrate the functional restoration of the wounded nerve. As it is chiefly at the extremities of the limbs that the areas of distribution of the nerves become overlapped in a complex fashion and muscles supplied by the different nerves are susceptible of developing these false supplementary restorations, it is in the movements of the hand and of the foot that should be found the tests of the cure of the paralysis resulting from a wound of the radial, the median, the ulnar, the sciatic nerves and their branches.

The tests proposed by Professor Pitres and which have been adopted are as follows:

For the *radial*, the recovery of the power of extension of the wrist and of the fingers, including the thumb, and the supination of the forearm. The patient who can put his upper limb in the attitude of taking an oath, the thumb extended and separated from the index finger, then without changing the position of his arm can bring his hand into a position of supination, is certainly cured of paralysis of the radial nerve. A second test, still more simple, is to place the patient upright facing front, the little finger upon the seam of the pantaloons, the palmar face directly forward.

For the *median* nerve, a ready test consists in the patient placing the hand flat upon a table and asking him to scratch the wood of the table with the nail of his index finger without moving his wrist at all. An excellent sign also is the sign of the fist which demonstrates very certainly the functional activity of the median nerve in the innervation of the muscles of the thenar eminence. In the act of closing the fist, in applying the palmar face of the thumb upon the back of the middle or of the fourth finger, there is brought into play the short abductor, the opponens and the short flexor. Patients who can make supplementary movements of the short abductor through the ulnar nerve cannot execute this movement.

For the *ulnar* nerve the movement of separation and approximation of the fingers, or more simple lateral movements of the middle finger alone, and the movement of flexion of the third phalanx upon the second at the level of the two last fingers present a certain proof of functional restoration of the nerve. It is sufficient to ask the patient to put his hand upon the table upon its palmar face and to carry the middle finger outwardly or inwardly, or to scratch the wood of the table with the nail of the little finger without bending the wrist.

The test for cure of the sciatic nerve or its branches is derived from the execution of simple movements of the foot. The patient being seated upon a chair, the feet resting flatly upon the ground, he is asked to execute the balancing movement in which he will rest alternately upon the ball of the foot and upon the heel. If his internal popliteal is alone paralyzed, he cannot raise the heel above the ground, but can very easily raise the point of the foot and carry it outward or inward. If he has paralysis of the external popliteal nerve, the conditions will be reversed. He will be able to

raise the heel, but he will be incapable of raising the ball of the foot from the ground. When he has become cured, he will be able to execute easily the alternate movements of balancing on the foot.

When these tests are complied with we shall have then a "cure." When there shall not be complete cure, but return of most of the voluntary and electric movements, we say there is a "great improvement." And finally, when there is return of sensibility more or less extensive, return of tonicity and some contractility, either voluntary or electric, we say simply, "improved."

I. *The Radial Nerve*.—Pursuing the study of each nerve by itself, the author first gives the results of 436 operations practised upon the radial nerve which have been sent in from the neurological centres. In 220 cases there was compression; in 13 incomplete division, in 203 complete division.

The operations done have been in 235 cases liberation; 190 cases suture.

Liberation and suture, for unfortunately the distinction is not always made, have given together 25 per cent. of improvement and of cures, 42 cures out of 235 liberations and 10 cures after 190 sutures.

The personal statistics of the author are as follows: Total number of operations done 144, for which 41 done too recently are to be eliminated, leaving 103 cases. Of these, 56 times there was compression, twice incomplete division, 14 times complete division without fibrous continuity, 31 times complete division with fibrous continuity.

1. The cases of *compression*, either by involvement in a callus, 14 cases, or by inclusion in a fibrous mass, 42 cases. Eleven patients have been lost sight of, one operated less than 10 months. Of the 44 remaining, there were 8 negative (18.2 per cent.). In 59 per cent. of the cases the results were very good or perfect.

2. *Incomplete Division*.—Two cases, one negative and one great improvement.

3. *Complete Division*.—Forty-eight cases: with fibrous continuity 34 cases, without fibrous continuity 14 cases. In 42 cases free resection was made of the fibrous tissue at each end, and an end-to-end suture was done, taking care to suture only the neurilemma. Six times, because of too great separation between the two nerve ends, it was necessary to make a graft, taking the graft from the cutaneous branch of the musculocutaneous nerve of the leg. Of the 42 cases, 12 were lost sight of, 9 were operated upon for too short a time for inclusion as to results. Of the remainder, there were negative, 10 cases (37 per cent.); slight improvement, 1 case (3.7 per cent.); considerable improvement, 9 cases (33 per cent.); cure, 7 cases (26 per cent.).

As to the six patients upon whom grafts were used, three have been lost sight of, and the three others observed at periods of three months, six months and 13 months, were not improved.

The author compares with his statistics those of Dumas in 115 operations upon the same nerve, comprising 18 cases of compression, 41 cases of incomplete division and 56 cases of complete division.

Of the compressions, Dumas' results were negative 6 per cent., incomplete regeneration 11 per cent., complete regeneration 83 per cent. These results of Dumas' after liberation are particularly good.

2. Incomplete divisions, 41 cases. The results have been negative 19 per cent., incomplete regeneration 70 per cent., complete regeneration 11 per cent.

3. Complete divisions, 56 cases. The separation of the two nerve ends 10 cases, with fibrous continuity between the two ends 46 cases. In the divisions with complete separation, although suture was especially indicated, in three cases only has suture been possible to be done with favorable conditions without too great tension of the two ends, with suture of the neurilemma. In three other cases it was possible to accomplish direct apposition, but with much tension, notwithstanding the minimum of resection of the terminal fibrous formations. In two cases a longitudinal plastic of the lower end was made. In one case a similar plastic from the upper end, and in one case the two ends were connected through a space of 3 cm. by a thread of linen.

In divisions with fibrous continuity, the cicatricial bridge was dissected out and the two ends of the nerve freed and protected from later compression by appropriate proceedings.

The results have been for the sutures: negative, 90 per cent.; incomplete regeneration, 10 per cent.; complete regeneration, 0 per cent. For the liberations: negative results, 47 per cent.; incomplete regeneration, 10 per cent.; complete regeneration, 43 per cent.

As an example of complete cure after suture of the radial, the author details the case of a soldier who was wounded on the 15th of September, 1914. He entered la Salpêtrière on the 21st of November, 1914, with a complete total paralysis of all the muscles of the left forearm that were supplied by the radial nerve. He was operated upon one hundred and twenty-five days after the wound, at which time there was found to be present complete division of the radial nerve. The two thickened ends were united by a cord of 3 mm. in length and 2 mm. in width. The lesion was seated at a point above that of the emergence of the branches supplying the long supinator and the radial muscles. After resection of the nerve ends, end-to-end suture was made. Histological examination of the fibrous band and the distal end showed that they contained no cylinder axis. Tonicity began to return shortly after the operation; it was very manifest by the thirty-first day; it was marked by the seventy-third day and continued to increase regularly, and by the one hundred and seventy-sixth day there was noted the first return of voluntary motility, faradic contractility being still absent. On the one hundred and ninety-second day after the operation the radial muscles along the supinator and the extensor indicis voluntarily contracted. On the other hand, the return of sensibility was still defective.

In another case which he presented to the Society of Surgery of Paris, Séance of March 7, 1916, all movements had equally become restored with the exception of some weakness in the extensor of the index. The case was in the service of Professor Marie. He was wounded on the 30th of

August, 1914, by a rifle ball which had fractured the left humerus in the lower third, with immediate radial paralysis. The reporter operated upon the patient upon the 3rd of February, 1915, and found in the external bicipital groove complete division of the nerve without fibrous continuity. The two nerve ends were swollen and separated to the distance of a centimetre. After resection of the two cicatricial ends, he sutured the two nerve ends together with silk; closure without drainage. The return of voluntary motility took place by the last of June, 1915, one hundred and fifty days after the operation. Movements had entirely returned in all the muscles supplied by the radial nerve, although still somewhat feeble in the long abductor of the thumb, the extensor proprius of the index, and the extensor of the thumb.

In a patient of Doctor Babinski there was paralysis of the radial with complete division of the nerve and painful phenomena following a wound which was sustained January 17, 1915. Operation was done three months and a half later, May 31. In September, 1915, the pain had disappeared. By the end of October there was noted a return of sensibility and of the movements of extension. By February, 1916, it was noted in the records that the patient was greatly improved from the point of motion and sensation without faradic contractility. By December, 1916, he could be considered as completely cured and was proposed for auxiliary service by reason of some feebleness of the hand and of the electric nerve reaction.

In a case of suture of a right radial nerve in a child a rapid and complete cure was obtained. The child, ten years of age, presented division of the radial nerve above the point of emergence of the branches of the long supinator and the radial muscles, the result of a knife cut. There was no infection of the wound and on the fifteenth day end-to-end suture was done for complete division. All the conditions were favorable and the little patient made a complete cure.

In the case of a lieutenant wounded on the second of July, 1915, and operated upon by the author on the 6th of March following, with free refreshing of the radial nerve, followed by end-to-end suture, and the protection of the nerve by animal membrane in July, 1917, there was found to have taken place functional restoration of all the territory supplied by the radial except in the long supinator, but electrical reaction was still quite defective.

II. *Ulnar Nerve*.—The figures for this nerve, supplied by the neurological centres, are as follows: Total number of operations done, 369. For compression, 174; for division with or without continuity, 195. Operation practised: liberation, 200; suture, 155; graft, 2. The results were reported *en bloc*, without those distinctions which are indispensable, as 129 improvements and 24 cures, one cure after graft; that is to say, improvements 39 per cent., cures 6 per cent.

The personal statistics of the author involve 151 cases operated upon, from which are to be subtracted 48 as too recent for use. The 103 cases remaining are divisible as follows: Compression, 48; incomplete division, 3;

complete division with fibrous continuity, 27; complete division without fibrous continuity, 25.

Of the cases of compression, 48 in number, 47 were cases of compression by inclusion in a fibrous mass, one a case of neuroma. The results have been negative in 9; that is to say, 28.1 per cent.; slight improvement 10 (31.2 per cent.); cure, 4 (12.5 per cent.).

Cases of Complete Division.—One case was negative; one considerably improved, and one patient lost sight of.

Complete division, 52 cases; with fibrous continuity, 27 cases; without continuity, 25 cases. Results: Negative, 17 cases (47.2 per cent.); slight improvement, 13 cases (36.1 per cent.); considerably improved, 3 cases (8.3 per cent.); cure, 3 cases (8.3 per cent.); 11 patients lost sight of. Five operated too short a time to be included in the report.

Certain cases are worthy of being reported in detail: One, a soldier wounded in December, 1914, was operated upon in 1915 for paralysis of the ulnar nerve. There was found a complete division of the nerve, the two ends of which were united by a fibrous cord. After free resection there was placed between the ends a piece of the musculocutaneous nerve. The graft was protected by an envelope of animal membrane (pericardium of a calf). By February, 1916, four months later, no improvement had appeared, but in December, 1917, fourteen months after operation, return of sensibility was evident.

Another soldier who was wounded in December, 1915, was operated in February, 1916, two months later, for ulnar paralysis. The nerve was found completely divided. After the ends were refreshed, an end-to-end suture was done with a protective wrapping of animal membrane. In February, 1917, one year after the operation, both voluntary movements and electric excitability had reappeared in the muscles of the hand and the troubles of sensation were considerably diminished.

III. *Median Nerve.*—Number of cases sent in from the neurological centres 191, divided as follows: Compression, 113; division, 78. Procedures resorted to: Liberation, 126, suture, 63; graft, 2. Results: Improved, 45 (25 per cent.); after liberation, 8 cures; after suture, 1 cure.

The personal statistics of the author in median nerve cases includes 108, of which it is necessary to subtract 28 as too recent for consideration. The 80 cases remaining are divisible as follows: Compression, 50; incomplete division, 5; complete division with fibrous continuity, 16; complete division without fibrous continuity, 9.

1. The compressions were all cases of inclusion in a fibrous mass. The results were as follows: Negative, 3 (10 per cent.); slight improvement, 13 (43.3 per cent.); considerable improvement, 12 (40 per cent.); cure, 2 (6.6 per cent.); 15 cases had been lost sight of and 5 had been operated upon too short a time before the report.

2. *Incomplete Division.*—Five cases. The results were negative in one,

considerably improved in one, two cases have been lost sight of and one operated upon too recently.

3. *Complete Division*.—Twenty-five cases. With fibrous continuity, 16; without fibrous continuity, 9. Results as follows: Negative, 7 cases (43.7 per cent.); slight improvement, 2 cases (12.5 per cent.); considerable improvement, 7 cases (43.7 per cent.). Seven patients lost sight of, two operated upon too recently.

One case was that of a captain wounded on the 22d of August, 1914, by a ball which fractured the humerus and produced a paralysis of the median nerve at the bend of the elbow. The patient was operated upon the first of April, 1915, eight months later. The nerve was found involved in a mass of dense sclerotic tissue from which it was disengaged. At the point of division it was considerably thinned and reduced to a vaguely fasciculated cylinder occupying the external border of the mass. Above the thinning was noted a thickening of the nerve. The nerve was divided above the swollen point, preserving 1 cm. more of the proximal end along the external border. After division below the thin part, suture was applied end to end according to the usual manner. The nerve was then protected by embedding it in a layer of muscle before uniting the superficial layers. On the eighty-eighth day mobility began. The patient could flex the two last phalanges of the index and of the middle finger as well as the second phalanx of the thumb. Pain on pressure of the median trunk could be elicited at the wrist and at the bend of the elbow. The tests of sensibility showed that the zone of anæsthesia was diminished. On the two hundred and fifty-seventh day flexion of the index and of the middle finger is complete. The movements of apposition of the thumb are perfect, the zone of anæsthesia has diminished to a small area in the vicinity of the nail of the index and of the middle finger.

It is interesting to note in this case that histological examination showed that it was correct practice not to keep the fasciculus corresponding to the outer quarter of the nerve, since a fibrous callus occupied the lower part of this fasciculus and would have placed an obstacle in the proliferation of the new cylinder axes of the central end.

Another case demonstrated the late results of nerve graft. A man wounded on the 24th of September, 1914, was operated on the 21st of February, 1916, for paralysis of the median nerve. The nerve was found partially divided and involved in a vague fibrous mass. After liberation of the ulnar nerve and of the median nerve, the fibrous part of the nerve was resected with preservation of the lateral track. Suture end to end was impossible because of the separation of the two ends, so that it was necessary to engraft between the two ends a segment of the internal cutaneous of the arm. By November, 1916, 9 months later, the patient was already much improved, both voluntary and faradic contractility had reappeared in the muscles. This improvement had continued at the beginning of 1917.

Another favorable case of nerve graft was that of a soldier wounded in August, 1914, operated in August, 1915, for paralysis of the median nerve

following a shell wound of the right forearm. The nerve was found divided above the wrist, and a graft from the musculocutaneous nerve of the leg was done. At the beginning of 1917 the patient could perceive the electric current at the extremity of the index finger; the reaction of degeneration had lessened in the thenar eminence and the muscles would contract under the faradic current. Although there were not yet any voluntary movements, the case justifies grafting in other cases where suture is impossible.

IV. *Musculocutaneous Nerve in the Upper Part of the Arm.*—Three such cases were reported from the neurological centres, all with fibrous compression. Of these one was reported as slightly improved, one as cured, one as lost from sight.

V. *Brachial Plexus.*—Reported by the neurological centres 54 cases: 29 of incomplete division; 23 of complete division. The procedures instituted in these cases were as follows: 30 cases liberation, 23 suture, one graft. Results obtained: 21 cases improved by liberation; 6 cases improved by suture; 5 cures after liberation; 2 cures after suture.

The personal statistics of the author included 43 cases, 9 of which are too recent for use. The 34 remaining cases comprise compression 28, complete division with fibrous continuity 6.

Compression by inclusion in a fibrous mass gave the following results: Negative, 2 (14.3 per cent.); slight improvement, 3 (21.4 per cent.); much improvement, 7 (50 per cent.); cures, 2 (14.3 per cent.). Thirteen patients have been lost sight of and one was operated too recently for consideration.

Complete division with fibrous continuity, 6 cases. Results have been: Cure, 2 cases (66.6 per cent.); much improved, 1 case (33.3 per cent.). Two patients lost sight of; one operation too recent.

VI. *Sciatic Nerve.*—Number of cases reported from the neurological centres 135, classified as follows: Compressions 46, divisions 89. Procedures resorted to: Liberation, 57; suture, 78. Results: Improvements, 54; complete cures, 2; both of which followed suture.

The personal statistics of the writer comprises 104 cases, 34 of which are recent. Of the remaining 70 cases there were compression 33, complete division with fibrous continuity 37. The results were as follows: Cases of compression by inclusion in a fibrous mass, 33 cases. Negative, 4 cases (21.1 per cent.); slight improvement, 6 cases (31.5 per cent.); much improved, 6 cases (31.5 per cent.); cures, 3 cases (15.8 per cent.); 9 patients lost sight of, 5 operated upon too recently for inclusion.

Complete division with fibrous continuity 37 cases, with results as follows: Negative, 7 cases (38.8 per cent.); slight improvement, 2 cases (11.1 per cent.); much improvement, 9 cases (50 per cent.). Eight patients lost sight of, 11 patients operated upon too recently.

In this class belongs the case, referred to earlier in this paper, of the commandant of one of the forts of Verdun, in whom was done a free resection of the sciatic nerve with end-to-end suture, in whom after eight

months there was a complete return of all movements and contractility by the internal popliteal of the sciatic nerve excepting adduction of the point of the foot.

The case of a soldier showed equally an example of late improvement. He was operated upon in July, 1915, for complete division of the sciatic nerve. He was pensioned and sent home without improvement, but on the first of April, 1917, he wrote that he was able to lower the point of the foot; that is to say, to extend the foot upon the leg. He added that this movement was preceded by sensations of prickling and crawling in the foot, so that it was not until twenty months after the operation that he was able to observe any result.

VII. *Internal Popliteal Branch of the Sciatic Nerve*.—Number of cases reported from the neurological centres, 42: Compressions, 16; divisions, 26. Operations done: Liberation, 21; suture, 17. Results: Improvement, 19 (45 per cent.).

Number of personal cases treated by the author 14, four of which are recent. Of the ten remaining, there were compression 3 cases, complete division with fibrous continuity 7; compression by inclusion in a fibrous mass, 2 cases; by metallic body, 1 case. Results: Slight improvement, 1 case; considerable improvement, 1 case; lost sight of, 1 case. Complete division with fibrous continuity, 7 cases. Results: Negative, 1; slight improvement, 1; much improvement, 1; cure, 1; lost sight of, 1; operated recently, 2.

VIII. *External Popliteal Branch of the Sciatic Nerve*.—Number of cases from neurological centres 106, of which there are compressions, 38; divisions, 68. Operations done: Liberation, 51; suture, 49. Results: Improved, 45; cures, 4.

Personal statistics of the author 44 cases, of which 8 are too recent to be included. Of the remaining 36 there were compression, 16; complete division with fibrous continuity, 16; complete division without fibrous continuity, 4. The compressions were all by inclusion in a fibrous mass. The results: Negative, 3; much improvement, 4; cure, 2. Seven patients were lost sight of.

Complete divisions, 20. Results of operation: Negative, 4; slight improvement, 5; much improvement, 9; lost sight of, 2.

The author relates the details of one man who was wounded September 12, 1914, and operated on the 25th of November of the same year on account of a syndrome indicating complete division of the external popliteal branch of the sciatic nerve in the popliteal space. There was found a complete division of the nerve, with separation of the two ends and cicatricial swelling of the lower end. The separation of the fragments was too great to permit of end-to-end suture. As up to that time the operator had not practised nerve grafting, he decided to double back a portion of the lower end and suture it to the upper end. By the first of June following, that is to say, at the end of two months, voluntary motility reappeared in the lateral peroneal muscles and had increased by September. In November the exten-

sors began to contract and in February, 1916, the patient, although not completely cured, could retake his place at the front in duty which demanded frequent marching.

IX. *Posterior Tibial Nerve*.—Number of personal cases 4, of which there were compression 2, complete division with fibrous continuity 2. The compressions were by inclusion in fibrous mass—one patient was cured and the other lost sight of.

Of the complete divisions with fibrous continuity, the result in one case was negative, one case slightly improved.

X. *Anterior Tibial Nerve*.—Number of cases operated upon 1, compression by fibrous mass, cured.

It happened once for the anterior tibial nerve that he was unable to practise suture because of the site of the lesion, which was situated exactly at the point where the anterior tibial gives off its muscular branches. The same thing happened to him also for the upper branch of the radial nerve in the thickness of the supinator brevis, the lesion, quite extensive, being exactly at the point of the division of the nerve.

Such lesions are not amenable to operative cure and it is necessary in such cases to seek by indirect methods the remedy, at least in part, of the paralytic troubles. Thus, in the case of the radial nerve one may have recourse to tendon anastomosis. Chutro has practised such an anastomosis between the tendon of the palmaris longus and the extensor tendons, which have given him satisfaction. Moynihan has also insisted upon the usefulness in certain cases of such tendon anastomoses to secure the restoration of the function of certain muscles whose nerves are not capable of restoration.

XI. *Crural Nerve*.—Number of cases reported from the neurological centres 7. Compression, 1; division, 6. Liberation was practised 4 times and suture 3 times, with 3 negative results and 4 improvements.

The personal statistics of the author comprise 4 cases, all of fibrous compression. Of these four patients, 2 were lost sight of; one gave a negative result and one a cure.

XII. *Operations upon Trunks Purely Sensory*.—Gosset's statistics comprised 12 cases: Internal cutaneous of the arm, 5 cases; external saphenous, 1 case; cutaneous branch of the musculocutaneous of the arm, 3 cases; internal saphenous, 3 cases.

In all cases there was present pain due to compression, or to neuritis in cases of complete division. Operation has consisted in the free resection of the fibrous mass and of the nerve. The following results have been obtained: 4 cases lost sight of; one slight improvement; 7 cured.

Intervention for the Relief of Painful Syndrome.—The question of painful phenomena in lesions of the peripheral nerve is still very complex. They may be divided into two groups:

1. Where the nerve alone seems to be affected and in which simple liberation of a mixed nerve compressed has caused the pain to disappear. Such cases are very frequent.

EDITORIAL COMMENT

TABULAR STATEMENT OF CASES OBSERVED BY M. GOSSET

TABLE I

SHOWING RESULTS OF OPERATIONS UPON THE NERVES ACCORDING TO THE OPERATION PRACTISED

	In percentages			
	Negative results	Slight impvmt	Considerable impvmt	Cures
<i>1. After liberation:</i>				
External popliteal sciatic.....	33.3	....	44.4	22.2
Radial.....	18.2	22.8	40.8	18.2
Sciatic.....	21.1	31.5	31.5	15.8
Brachial plexus.....	14.3	21.4	50.0	14.3
Internal popliteal sciatic.....	.....	50.0	50.0	.....
Median.....	10.00	43.3	40.0	6.6
Ulnar.....	28.1	28.1	31.2	12.5
<i>2. After suture:</i>				
Brachial plexus.....	.....	....	66.6	33.3
Radial.....	37.00	3.7	33.3	26.0
Sciatic.....	38.8	11.1	50.0	....
External popliteal sciatic.....	22.2	27.7	50.0	....
Internal popliteal sciatic.....	25.00	25.0	25.0	25.0
Median.....	43.7	12.5	43.7	....
Ulnar.....	47.2	36.1	8.3	8.3

TABLE 2

SHOWING DATE OF RETURN OF FIRST VOLUNTARY MOVEMENTS AFTER NERVE RESECTION AND END-TO-END SUTURE

	Minimum	Maximum	Average
Median.....	3 months	11 months	6 months 23 days
Radial.....	4 months	13 months	8 months
External popliteal sciatic.....	7 months	14 months	10 months 23 days
Internal popliteal sciatic.....	8 months	14 months	11 months
Ulnar.....	7 months	19 months	11 months 11 days
Brachial plexus.....	12 months	13 months	12 months 15 days
Sciatic.....	12 months	21 months	16 months

TABLE 3

SHOWING DATE OF RETURN OF FIRST INVOLUNTARY MOVEMENTS AFTER NERVE LIBERATION

	Minimum	Maximum	Average
Radial.....	1 day	9 months	3 months 27 days
Brachial plexus.....	1 month	9 months	4 months 15 days
External popliteal sciatic.....	15 days	12 months	4 months 21 days
Median.....	1 month	11 months	5 months 5 days
Ulnar.....	3 days	11 months	5 months 15 days
Sciatic.....	1 month	14 months	8 months

Simple liberation of the nerve does not always give complete relief. Scarification of the nerve cicatrix in cases where motility was preserved may be added. In one of the cases of the author such a scarification of the median caused the pains to almost totally disappear in from 8 to 10 days.

2. Aside from the simple cases there are many others much more complex in which the cause of the pain appears to be due to an association of nerve and vascular troubles. It is for these complex cases, the pathogeny of which is still under discussion, that sympathisectomy has been practised, under the theory that such cases are to be considered as an expression of a sympathetic neuritis.

Tests after Surgical Intervention upon Nerves to Determine Whether the Operation is a Failure or if There has been Functional Restoration.—There are certain cases of immediate motor restoration, paradoxical cases, of which pathological anatomy and experimental research give no explanation, but of which there exist some examples.

The rapid restoration of motility the day after, or the next day after, a suture is an idea incompatible with clinical teachings or with those of pathological anatomy or experimental research. After division of a nerve the distal end always degenerates and throughout its whole extent if the division is total. Spontaneous regeneration of the distal end except after full reunion with the central end of the divided nerve rests upon no histological or experimental fact. In order that the peripheral end may regenerate, it is necessary that the new cylinder axes issuing from the central end should penetrate into the cicatrix and innervate it until they enter the peripheral end and traverse it throughout its whole length. The regeneration of this peripheral end is accomplished progressively from above downward, and if the nerve possesses, as in the upper limb, for example, an area of muscular distribution for the forearm and another for the hand, function will begin to return in the forearm segment and will be observed only later for the muscles of the hand.

As to the return of motility before the return of sensibility, this is a fact often noted. During the time, always long, which elapses between the application of the suture and the return of voluntary motility, the time occupying 6, 8, 12, 15, 20 months and more, there exist according to the height of the lesion and the length of the track to be restored clinical signs which make it possible to affirm that regeneration of the peripheral end is going on, and which permit the surgeon together with the neurologist to await with confidence the ultimate restoration of motor and sensory function in the sutured nerve.

The two chief clinical signs of restoration are: (1) The progressive return of muscular tonicity which modifies the attitude of the limb and permits its better utilization; (2) the appearance of zones of paræsthesia in the territory of skin deprived of feeling supplied by the divided and sutured nerve.

These signs are early. Dejerine has noted the appearance of zones of paræsthesia about the seventeenth, twentieth, twenty-seventh days after suture and a return of muscular tonicity appreciable to the sight in from twenty-five to thirty days after suture.

Another important sign of regeneration is the spontaneous pains radiating along the course of the divided and sutured nerve. Dejerine insists upon the

character of these pains which sometimes assume the character of sensations of bruising, sometimes of dartings, sometimes of electric shocks, sometimes of crawling. They come on at periods of eight to fifteen days and seem to accompany the steps of growth of the cylinder axes, for their appearance often coincides with a lessening of the zone of dysæsthesia, or with a return of tonicity.

The pains and twitchings, which pressure on the nerve trunk provokes below the suture, are often reported by the subject as felt in the territory of the skin whose sensitiveness has been diminished by the wound of the nerve, and one can follow thus from week to week the progress of the new nerve fibres into the peripheral end. However disagreeable it may be for the patient, the appearance of these paræsthesical troubles, subjective and objective, give pleasure to the neurologist, for they bring to him proof that the sutured nerve is in the way of becoming restored.

On the contrary, the absence of any returning sign of tonicity and the absence of any paræsthesic zone indicate that the restoration of the sutured nerve is not taking place.

As to the Causes of Failures after Intervention.—Renewed intervention after failure has taught, except in cases where the separation was already too great at the time of the first intervention, that many of these failures are due to faulty operations; faulty methods which should be abandoned, as suture *à distance* or suture by doubling back a nerve flap, insufficient resection of the cicatricial nerve-end which has left upon the two extremities of the nerve, or upon one of them a fibrous cap through which the cylinder axes cannot pass, or a suture which, notwithstanding sufficient resection has been done under bad conditions, because the axis of the nerve has not been preserved carefully enough, or because the suture has not been absolutely through the neurilemma, or because the two extremities of the nerve have been too forcibly brought into coaptation with each other, producing thus a turning back of the nerve fasciculi. In order that a suture upon nerve ends which have been properly refreshed may result in functional restoration it is necessary to bring together a group of conditions, the importance of which is capital, and it is sufficient that one of these conditions should be omitted in order to produce a failure. Even in case where suture is done in a satisfactory manner, it may not give desired results because under the influence of traction the sutures may give way. Or again, because the suture well done has not been protected with sufficient care. Here is a precaution of the greatest importance, wide and careful resection of surrounding fibrous tissue and special isolation and protection of the nerve trunk by one of the numerous methods which have been suggested.

Finally, there is a last cause of failure of which it is necessary to think, that is a mistaking of the real nerve lesion. Of this the following is a typical case. In a lesion of the radial nerve by the first intervention the radial nerve was liberated from a fibrous mass; the case appeared to be favorable, but at the end of some months there was no sign of functional restoration. At a

re-intervention it was found that, at a point above the point where the liberation had been done, the radial nerve was completely divided. The two trunks of the nerve were then resected, sutured, and ultimately a good result was obtained.

As to the final results of the operations practised upon nerves during the first years of the war much further information is desirable. Now, however, the question has completely changed its character. It is no longer as a secondary operation that suture should be done in nerves of which functional restoration has not occurred and in which the clinical examination reveals grave lesions, but as an operation to be done immediately after the wound. It is as a part of the primary or secondary closure of wounds that the re-establishment of the continuity of the nerve trunks should be effected.

Gosset has had opportunity to operate upon several nerve wounds in conditions in which it was possible to practise immediate suture. In one case, a soldier was operated upon 53 hours after the wound, for a fracture of the lower extremity of the humerus and of the upper extremity of the ulna. After having made an atypical resection of the elbow, followed by securing the bone fragments together by metallic suture, he found a divided ulnar nerve. The two ends of the nerve, slightly contused, were refreshed and then sutured by four points of silk. The suture was covered in by a plane of muscle. When the patient was transferred a month later, examination showed that there was not yet any motor or sensory recovery, but pains under pressure along the nerve trunk warranted the conclusion that regeneration was beginning.

In another case, that of a soldier who was operated upon two hours after multiple injuries by shell fragments, one of the fragments had entered the left popliteal space and completely divided the external popliteal branch of the sciatic. After refreshing the two ends they were sutured together by four points of suture. On the fifteenth day thereafter examination showed typical paralysis of the external popliteal branch of the sciatic. Three months later the point of the foot fell less than in cases of non-sutured paralysis; loss of tonicity was much less great. There was noted neither circulatory nor atrophic troubles. Five and a half months after the wound, the patient could make the movements of adduction of the foot with elevation of the internal border; the anterior tibial had regained its functions; the extensors had not yet begun to function, the adduction of the foot was not possible; the fall of the point of the foot was less marked; muscular tonicity had reappeared in almost all the muscles; tactile sensibility was absent only in the lower third of the external face of the leg; sensibility to pain was perceptible everywhere, although slightly diminished. The patient halts in walking, but he can raise the point of the foot, which does not drag upon the ground. Electrical examination shows diminution in the reaction of the external popliteal branch of the sciatic nerve and of the muscles, but the return of reaction at the level of the tibialis anticus. To the galvanic current the reaction of degeneration is still clear. There is, then, notable improvement.

From such observations one may conclude that primary suture presents considerable advantages. It simplifies the operative technic, since no adhesions fix the extremities of the nerve. Very limited refreshing suffices to bring healthy cylinder axes into contact with a permeable inferior end whereby are eliminated all those failures due to persistence of the nerve keloid. There is considerable time gained toward a final cure together with advantage to the rapid reestablishment of the trophic and tonic function of the nerve.

This is the real desirable method of treating wounds of the nerves. Unfortunately, those patients operated upon for nerve lesion at the hospitals at the front will risk being lost sight of, so as not to be subjected to scientific study, unless care is taken to provide them with a special ticket and to direct them to the special centres. But the knowledge gained up to the present warrants the belief that immediate suture of nerves will give functional restorations more frequent, more complete and more rapid.

If nerve suture has not given the percentage of successes one might have hoped, it is because it has been done late, after prolonged suppuration, upon nerve ends separated too far and transformed into fibrous tissue. But nerve suture even done late still has more value in the case of complete division than expectancy, as proof of which the subjoined figures are submitted.

The *Commission Consultative Medicale* which has to do with pensions, or with gratuities to be given to the pensioned, has furnished for study 33,638 records. Of 10,214 wounds of the forearm, without amputation, resulting in pension, there were: 865 wounds of the radial nerve; 1314 wounds of the ulnar; 696 wounds of the median nerve; 870 cases in which there were associated lesions, radial and ulnar, radial and median, median and ulnar, ulnar and median. These 3765 pensioners have nerve lesions which have not been subjected to any operations.

Of 4492 pensioners with nerve lesions of the lower limb, 1420 only had been operated upon.

Immediate suture of the nerves which should be done systematically in the hospitals at the front should prevent in the future any such proportion of pensioners on account of nerve lesions.

JOYCE ON PERIPHERAL NERVE INJURIES

IN the January issue of the *British Journal of Surgery*, page 418, *et seq.*, Brevet-Major J. L. Joyce, R.A.M.C.T., contributes a paper devoted to the study of war injured nerves, dwelling mainly on the operative treatment. The material studied includes 150 cases of injured peripheral nerves which were under the care of the writer in a war hospital during the period from May, 1915, to April, 1918. Since the latter date fifty additional cases have been recorded in the same hospital.

EDITORIAL COMMENT

The nerves involved were as follows:

Ulnar nerve	23
Musculospiral	18
Median	17
Brachial plexus	13
Median and ulnar	11
Circumflex	2
Posterior interosseous	2
Musculocutaneous	1
Internal cutaneous	1
Suprascapular	1
Ulnar and posterior interosseous	1
Median ulnar and musculospiral	1
Median and internal cutaneous	1
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Total nerves of the upper limb injured	92
Trunk of the sciatic	18
External division of the sciatic	12
Peroneal nerve	7
Posterior tibial	6
Internal division of the sciatic	3
Anterior crural	1
Anterior tibial	1
Obturator	1
Musculocutaneous	1
External saphenous	1
Peroneal and posterior tibial	1
Posterior tibial and external saphenous	1
Sciatic trunk left and sciatic external division right	1
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Total nerves of lower limb	54
Supraorbital nerve	3
Cervical plexus	1
<hr/>	
	4

The number of operations performed was 90, as follows:

Neurolysis (liberation)	39
Delayed suture	23
Total exsection and suture	6
Partial exsection and suture	7
Autogenous transplantation	4
Total exsection and autogenous transplantation	1
Homologous transplantation	1
Double lateral implantation	3
Exploration	6

1. *Nerve Transplantations and Double Lateral Implantations.*—This group comprises 5 ulnar, 1 median, 1 sciatic, and one posterior tibial lesions in which end-to-end union could not be obtained on account of the long gap between the divided ends. Of these, two of the ulnar, and the median, sciatic, and posterior tibial cases, were dealt with by autogenous transplants

from the radial. One ulnar case was bridged by a homologous transplant of the external popliteal nerve. In the two remaining ulnar cases a double lateral implantation of the divided ends into the neighboring median nerve was done.

The following is a brief summary of each of these cases:

CASE I.—Complete division of ulnar and posterior interosseous nerve; subjected to operation seventy-five days after the primary wound. The bulbous ends of the separated trunk were resected until healthy fasciculi were visible. A gap of $2\frac{1}{2}$ cm. persisted even after the wrist had been placed in flexion. This gap was bridged by two pieces taken from the radial nerve each $2\frac{1}{2}$ cm. long. The suture line and transplant were wrapped in Cargile membrane. The posterior interosseous nerve freed from callus and wrapped in Cargile membrane. Ultimate result at end of twenty-eight months, partial motor and sensory recovery.

CASE II.—Complete division of the ulnar nerve from wound sustained twenty-three months before operation. At operation complete section of ulnar nerve found present. Bulbar expansions of central and peripheral segments excised. Gap between the two segments of 3.6 cm. was filled by transplanting one piece of the radial nerve. Ultimate result at end of sixteen months, partial motor and sensory recovery.

CASE III.—Complete division of sciatic nerve, result of gunshot wound of left thigh. Operation nineteen weeks after injury. Complete division of sciatic nerve. Both ends bulbous and involved in large bony callus. After liberation, stretching and resection, a persisting gap of $2\frac{1}{2}$ cm. was bridged by three pieces of radial nerve from patient's forearms. The bridge was surrounded by Cargile membrane. Ultimate result, partial motor and sensory recovery.

CASES IV and V.—Median at the wrist, and posterior tibial above the ankle. In both a gap was bridged with autogenous transplant from the radial. At end of six months in both, some sensory recovery. No return of muscular power.

CASE VI.—Complete section of ulnar. Operated upon six months after injury. Gap of $3\frac{1}{2}$ cm. bridged by autogenous transplant of radial. One year after still complete paralysis motor and sensory. Site of operation exposed by incision. A large oval neuroma densely adherent to surrounding muscles found at upper end of transplant. This bulb when liberated from the compressing scar tissue which surrounded it presented normal nerve tissue in size, shape and consistency. A smaller and similar bulb was found at the lower end of the transplant. Seventy-nine days after this neurolysis, some sensory recovery and progressive sensations of formication had appeared.

CASE VII.—Complete division of ulnar nerve with loss of 12 cm. of its substance at elbow. Operation ten months after injury. Upper and lower segments transposed to front of elbow and approximately by flexion of the joint until the distance between them was $7\frac{1}{2}$ cm. The gap was filled by a segment of the external popliteal nerve previously removed from a case of irreparable injury to the anterior tibial and peroneal branches. Suture lines wrapped in Cargile membrane. Seven months later, no motor or sensory recovery having become evident, the nerve was exposed. A soft spindle-shaped neuromatous enlargement was found present at the junction of the upper segment with the transplant. A second neuroma of similar size was present at the junction of the transplant with the lower segment. No conduction of faradic current through the transplant. The transplant was freed from scar tissue and the wound closed. Two months after this neurolysis, progressive formication below the level of the transplant was developing.

The author commenting upon these cases remarks that Cases II and III show that both sensory and motor recovery do occur after nerve transplantation, although in neither case was recovery complete.

In Cases IV and V improvement had taken place at the time of report and in Cases VI and VII it was evident that the axis cylinders had begun to penetrate into the lower segments. The ultimate amount of benefit to be experienced in these cases is still undetermined. Recovery after a nerve transplantation certainly occurs much more slowly than after an end-to-end suture.

Of the three cases of total lateral implantation only one has been followed long enough to speak of the ultimate result.

This was a case of shell wound of the left forearm sustained in May, 1915, and operated upon in February, 1916, ten months after injury. Ten cm. of the ulnar nerve were found to have been totally destroyed, and, after resection of the bulb ends from the segments and excision of the intervening scar, there was a gap between the fragments of 13 cm. Approximately one-third of the circumference of the median was divided on the ulnar side at two points 16 cm. apart, and the upper and lower ends of the ulnar segments were respectively implanted into the median at these two points. The next August, six months later, there was no recovery of motor power in the muscles, but appreciable restoration of sensation. At the end of twelve months his medical attendant reported that he was able to close all his fingers and give a good grip, with uniform sensation in both back and front of hand; feeling not quite as good as in his right hand, but improvement still progressing. Nine months later, twenty months after operation, personal report made by patient is that he has nearly all the feeling restored to his hand, the most sensitive being the little finger. The man is still in the army and has a useful hand.

The opinion of the author is that the portion of the median nerve between the lateral cuts acts as a pedicled neurovascular autotransplant and is more likely to succeed than a free autotransplant.

Operative Technic.—The upper end of the nerve is usually defined first and the bulb carefully dissected from the adhesions to the surrounding structures. The lower end is then sought for, found and dealt with in the same way. The intervening scar is carefully excised. All the chief bleeding points are ligated and all of the oozing is checked by gauze pressure, oversewing, and by swabbing out the wound by adrenalin 1 to 1000. The obtaining of a dry wound before proceeding with the next stage of the operation is deemed an important point.

When the wound is quite dry, the gap between the divided ends is carefully measured and a rough estimation of what the gap will be when the bulbs have been resected, and decision made as to the steps necessary to bring together without tension the ends of the nerve left after the removal of the bulbs.

After this has been carried out, the bulb on the central end is first removed in successive slices by a sharp knife until healthy nerve fasciculi are seen protruding from the cut face of the nerve. Similar resection of

EDITORIAL COMMENT

the distal segment is made. A tension suture of fine catgut is now passed through the centre of both segments and the ends are drawn together. Two continuous sutures of the finest catgut procurable draw the sheath together, one suture being used for each half of the circumference of the nerve. At this stage the tension suture is generally removed, but if there has been any difficulty in drawing the ends of the nerve together, it is tied and left *in situ*.

The suture line and the nerve for $2\frac{1}{2}$ cm. on either side are then wrapped in Cargile membrane. In some cases a further covering of free or pedunculated flaps of fat or fascia have been used. In other cases the nerve has simply been placed between healthy muscles.

The muscles which have been drawn out of the way by retractors are now allowed to fall into position and the wound is closed with layer sutures.

With regard to the results recorded after work upon divided nerves, it is quite certain that, after delayed suture, complete recovery, in the sense that no differences can be found between an affected and a normal limb, is seldom if ever attained. In the best cases there will remain a dulling of the finer forms of sensation, some slight wasting of the affected muscles, or a greater liability to fatigue on the affected side. In tabulating the results, however, the word "recovery" is used in those cases in which there has been complete return of protopathic sensations, recovery of useful voluntary movements in all the affected muscles, with return of faradic response.

"Considerable improvement" denotes complete return of protopathic sensation, recovery of some voluntary movements in affected muscles, with or without response to faradism.

"Improved" denotes some return of protopathic sensation with or without early voluntary twitchings of one or more of the affected muscles, with or without response to faradism, and definite and progressive formication on percussion over the nerve below the level of the lesion.

"No result" comprises all other cases and includes those that have been lost sight of and those in which sufficient time has not elapsed to estimate the result.

TABULATED STATEMENT OF RESULTS OF NERVE SUTURE

Recoveries	8
Considerable improvement	6
Improvement	8
No result	14
	—
Total number of cases	36

AVERAGE TIME UNDER OBSERVATION SINCE OPERATION

Recoveries	15 months
Considerable improvement	7 months
Improvement	3 months
No result	7 months

EDITORIAL COMMENT

Neurolyses.—Neurolysis consists essentially in the exposure of the nerve and in the removal of the causes of compression, such as osseous callus, fibrous masses, or cicatricial band. For all doubtful cases a good and uncomplicated suture is much better than a poor liberation. The thickened portion of the sheath of the nerve must also be removed. To this latter procedure is given the term "capsulectomy."

After such capsulectomy, the next and probably the most important step is to protect the delicate nerve spindle which has been stripped from its sheath, and to prevent its compression by fresh adhesions, or the contraction of new scar tissue. The natural bed for a nerve is an intramuscular space and in every case such space is to be sought for. It will usually be possible to lay the nerve in healthy tissue between the muscles, but in some situations, as, for example, the musculospiral in its groove, the attainment of such a bed for the nerve is impossible. In such cases the nerve is wrapped in Cargile membrane. The finer varieties of the membrane should be chosen. The author has explored four nerves which had been protected with Cargile membrane at respectively three, four, seven and nineteen month intervals. From his observations he concludes that such membrane is absorbed in less than six months, during which time it fulfils its purpose in protecting the nerve from compression and adhesions.

Neurolysis combined with capsulectomy can not be expected to effect a rapid cure except in cases of pure extraneural compression.

In the cases of neurolysis under study, 39 in number, there was complete physiological interruption of the nerve without loss of anatomical continuity, but with no sign of regeneration in the segment below the injury in 17.

Number of cases resulting in recoveries	8
Considerable improvement	6
Improvement	3

The recovered cases comprise 2 ulnar, 1 musculospiral, 1 musculo-cutaneous, 1 posterior interosseous, 1 sciatic, 1 posterior tibial and 1 brachial plexus injury.

The remaining 22 cases of neurolysis were performed either for incomplete physiological divisions which were not recovering satisfactorily, or for the relief of pain, resulting in recovery, 2; considerable improvement, 6; improvement, 2.

CONCLUSIONS

The writer, as the result of this study, presents the following conclusions:

1. In the majority of cases delayed end-to-end union of a divided nerve is successful, and this method of repair is that of choice.
2. As to the reunion of nerve trunks by suture of bulbs, the value of such method is still unsettled, but is deserving of further study.
3. The anatomical continuity of a nerve deserves the greatest respect.

4. Exploration of a physiologically completely divided nerve should be done as soon as the condition of the wound permits.

5. Neurolysis combined with a capsulectomy of spindle-shaped neuromata has been followed by recovery in most and improvement in all cases in which this has been done.

6. Exsection of a spindle-shaped neuroma is not justified unless failure has resulted from a neurolysis capsulectomy.

7. Nerve transplantations and double lateral implantations of the ulnar into the median of the forearm have been followed with some measure of success, including some recovery of voluntary power in the affected muscles, but recovery is slow and uncertain.

8. Nerve growth takes place from both ends of a divided nerve and from both ends of nerve transplants, but axis cylinders grow down only from the central end.

9. An autogenous nerve transplant of smaller size than the nerve into which it is planted is capable of hypertrophy.

10. Axis cylinders, judged by Tinel's sign, grow at the average rate of 2 mm. per day.

11. Perineural scar tissue constricting young axis cylinders is the most important factor in hindering recovery.

WILLEMS ON MOBILIZATION IN THE TREATMENT OF INTRA-ARTICULAR FRACTURES*

IN a discussion before the Interallied Surgical Conference on the 6th of November, 1917, Dr. CHARLES WILLEMS, of Belgium, after remarking that the symptomatology and the treatment of an articular wound was far from being always the same owing to differences in the degree of gravity of the bony lesion, suggested, as a useful classification founded upon the degree of the bony lesion, the following:

1. Articular wounds with slight bony lesion.
2. Articular wounds with moderate bony lesions.
3. Articular wounds with extensive bony destruction.

In the first two classes, the articular lesion takes precedence over the bony lesion and treatment involves the latter only to a slight degree. In the third variety, on the contrary, the bony lesion is the preponderating element toward which the treatment must be directed above all other things.

I. *Articular Wounds with Slight Bony Lesions.*—In this category are included simple perforations of the epiphysis, whether the perforation be complete from side to side, or incomplete with retention of the projectile in the bone; and in addition, cartilaginous erosions with or without superficial bony chips and losses of substance of muscle; deeper wounds but still limited to a slight extent of surface. All these lesions have this in common that

* Comptes-Rendus de la Conference Chirurgicale Interalliee pour l'etude des plaies de guerre. 3d Session, 5-8 Novembre, 1917.

they leave intact the greater part of the articular surface and that they are not accompanied by any line of fracture extending into the epiphysis producing detached or detachable fragments. They are not exposed to any displacement. It is this latter element which gives them their special characteristic and determines the treatment applicable to them.

This treatment is simple, namely, that which belongs to articular wounds without bony lesions. It includes excision of the borders of the wound or the wounds, and resection of the entire track through the soft parts. It involves the removal of splinters, smoothing of the bony wound and finally, the complete closure of the joint without drainage; that is to say, in cases which are seen during the first hours before infection. In other cases it is necessary to leave an opening for drainage.

The later treatment does not differ from that appropriate to cases where the bony skeleton has not been affected. Here the author's practice departs from the generally accepted rules.

Immobilization for every joint lesion is still almost a surgical dogma. It is practised by every one. The bolder surgeons grant, at most, that it is often kept up too long. The author, however, has not only done away with immobilization, but he has replaced it by mobilization, active mobilization. This he believes to be of very great importance. Not only does he do away with immobilization but in addition he obliges the patient to move his joint without delay and without ceasing.

Without entering into a detailed description of the technic of his method, he recalls certain essential rules.

The patient, furnished with a simple dressing not too tight, is encouraged to make movements from the time that he awakens from his anæsthesia. He always obeys, if not at once, at least after it has been insisted upon. As soon as he is convinced that movements are possible and not too painful, he will continue to make them without being asked to do so.

The technic of active mobilization will not be the same for all joints. For the elbow there will be movements of extension and of flexion. For the joints of the lower limb there will be, first, analogous movements; but as soon as the effects of the anæsthesia have passed off, walking should be added. The end to be attained is, in fact, to return the articulation to its function.

The possibility of immediately regaining function is a fact which astonishes whoever is unacquainted with the method. It astonishes also the patient, whose confidence rapidly increases.

Of course, the excursions to which the movements will be carried vary according to circumstances. The courage of the patient, his skill in bringing into action muscles which should contract, are elements which have to be taken into account. The extent of the lesion seems to have much influence.

The rapidity of the cure will evidently be affected by these factors, but it is always much more rapid than when the classical treatment has

been followed. The quality of the cure is also infinitely better, the joint mobility remains intact and the muscular atrophy though not entirely absent is at least reduced to a minimum which does not affect the function.

Immediate active mobilization, according to his experience, has not given rise to any accident. The only incident that one sometimes observes is the production of hemarthrosis which is evidently the result of the lesions and not of the movements. It is interesting to note that this effusion at once puts a stop to the movements, but as soon as the liquid is withdrawn by puncture, mobilization instantly is re-established, which means that it is not the wound which abolishes the function but the articular distention.

The consequences will be much more simple as the lesions of the skeleton are restricted in their extent. A limited loss of substance, even though quite deep, will be followed by less disadvantage than the removal of a chip superficial but extensive.

The most unfavorable conditions are the wide loss of substance from the cartilaginous covering. In such cases he has had much difficulty in maintaining the articular mobility.

The results obtained may be considered as definitive, since he has seen them maintained after long months as complete, and even more complete than at the beginning.

II. *Joint Wounds with Moderate Bony Lesions.*—By the term moderate bony lesions are to be understood those which have caused a detachment of an important fragment of an epiphysis, or which have led to such detachment. Such are fracture lines crossing the condyles obliquely. Even when the fragment is not entirely detached, the injury involves the interarticular line where the fixation of the epiphysis is lessened. Its displacement would have the effect of modifying the form of the interline and to compromise the statics of the articulation.

This class of lesions is much more grave from the point of view of function than those of the first category. It is not that the bony damage is necessarily greater, it is often less. What gives it its character and its gravity is the danger of disturbance of the joint line, a danger which must be guarded against in treatment.

Immediate active mobilization is perfectly applicable to these lesions. It is neither more difficult nor more painful than in the articular wounds of the first category. Quite extensive excursions are rapidly reached and also perfect results can be obtained. When the upper limb is involved, and in particular the elbow, there is, indeed, no special precaution to be taken and the limb may be abandoned to active movements quite as if a small lesion was present. The fracture becomes consolidated after very short delay and function is fully preserved. This important point is one easily verifiable by photographs. The fracture line is never the point of departure for an articular exostosis as is often the case when fractures of the elbow are immobilized. On the contrary, the movements have the

effect of clearing the interline and of directing the growth of callus eccentrically. If some little displacement of the condyloid fragment is produced, it will never be toward the joint, but upward, so that in this case there will never be intra-articular accumulations. This slight ascent of the fragments can be seen very clearly in radiographs taken after the cure.

For the knee a certain prudence is necessary. The movements of extension and of flexion should be begun immediately in bed, but walking should be delayed until the moment when the fracture has reached a degree of consolidation sufficient to remove all fear of displacement of the fragments. This requires about three weeks. As soon as walking is permissible, the further treatment is identical with that recommended in cases of minor lesions.

III. *Articular Wounds with Extensive Bony Destruction.*—In this group the anatomical lesions are extremely variable as to localization, form and extent, but as to treatment they can be brought into the two categories, first, great losses of substance, and the second, comminuted fractures. Whether one has to do with loss of substance or with a comminution, the conditions are very different according as the lesion has affected a single epiphysis or both. We have then, in fact, to consider four groups of fractures, namely, losses of substance of one epiphysis, losses of substance of two epiphyses, comminution of one epiphysis, comminution of two epiphyses.

(A) *Extensive Losses of Substance from One Epiphysis.*—There may be a large mass torn away in one or several pieces from one side of the epiphysis in such fashion that the corresponding part of the other epiphysis has lost its contact and bearing. The extent of the joint surface is to that extent diminished and the whole articular static is disorganized.

In the case of the elbow, its functional activity will not be very much hindered because this joint does not have to support strong pressure. There will result simply such a degree of bowing of the limb as shall be needed to bring the separated surfaces into relation with each other. The deformity will not alter practically the function. It is quite different at the knee. Here it is not only a question of mobility, but rather of solidity. Now, it is to be feared that a knee which no longer articulates by a part of its surface will be bent to the side opposite to that where the loss of substance is, and will no longer have the necessary firmness to support the weight of the body. Hence, the opinion held by many surgeons that owing to the bad probable functional result it is not best to seek for cure with preservation of mobility, but to remove the articulation by a primary resection.

This opinion does not seem to the author defensible. He has applied in these cases active immediate mobilization, and his report is that, in cases of injury of the elbow, the patient who has sustained this variety of intra-articular fracture will make the movements of flexion and extension as quickly and as easily as if the lesion had been one of lesser degree. The functional result of the mobilization will be excellent. At the be-

ginning there will be some lateral mobility, but this is lessened by use and finally disappears. Whatever may be the condition, the result will be much better than that of the best resection and a primary resort to such an operation is not to be considered. It will be very rare that it will be found necessary to practise it as a secondary resort if active mobilization in its full degree is used. Some lateral flexure alone prevents the result from being perfect, but such æsthetic imperfection should not justify a resection.

The question is more complicated for the knee. As long as the patient is recumbent, the knees fare exactly as in the case of the less important lesions; flexion and extension may be executed quite as well, but when the patient rises and attempts to walk the knee bends markedly to the side opposite to that in which the loss of substance is present and the patient can not support himself upon the limb.

But this lack of power may be only transient. Give the patient a supporting apparatus, as, for example, a Thomas splint, with a joint at the level of the knee and walking becomes possible. After some days of such exercise, the apparatus may be taken away and the patient will be able to walk without any support. A certain lateral mobility will persist for a certain time, but it will go on diminishing from day to day. Finally, the patient, as a rule, will walk with a movable knee which is sufficiently firm. Sometimes the permanent use of an articulated knee splint is necessary.

What goes on in this joint to overcome the tendency to lateral bending and to abnormal mobility? At the beginning it is the voluntary contraction of the muscles on the side opposite to the lesion which keeps the limb straight. The patient lends himself perfectly to the necessary effort which is at first considerable, but which diminishes rapidly. It is probable that at any given moment the muscular contraction is supplemented by a retraction which takes place in the capsulo-ligementous armament on the injured side, a retraction which serves to strengthen the uniting bands on that side and to produce a more solid fixation of the articulation. Whatever it may be, it is certain that the fibrous tissue which fills up the loss of substance plays little part in hindering the lateral deviation.

In the author's opinion, therefore, this variety of bony lesion does not constitute an indication for immediate resection, the functional result of which can not be compared with the preservation of the length of the limb and of the articular mobility.

It is obvious, however, that this method is applicable only within certain limits of bony destruction. These limits can not be fixed *a priori*, for one patient will get good use out of a knee which would be useless to another. However, there is a maximum limit beyond which the articular contact becomes manifestly insufficient and where preservation of mobility ceases to be desirable. According to the author's experience, such limit is the disappearance of a little less than half of the epiphysis. As

long as there remains, for example, a third of the width, function may be preserved. This conclusion is applicable only to the knee, whether it is the femoral condyle or the tibial surface that is involved. In the elbow more extensive lesions can still be given the benefit of conservative treatment.

In the knee where all of one condyle or half of the tibial articular surface has disappeared, the conservative course still should be tried. Resection should be resorted to only as a secondary measure, if it is found at last that the firmness of the articulation is not sufficient. It may happen that the result is better than could have been expected.

(B) *Large Losses of Substance of Two Epiphyses*.—In this class of cases there exists on one side of the joint an extensive loss of substance, while on the side opposite the articulation is intact. There is often at the same time an extensive destruction of the soft parts, so that the bony foyer is freely exposed.

As a principle, the treatment should not differ from that which has just been discussed for cases in which one epiphysis alone is involved, namely, excision of the wound, cleansing of the bony foyer, closure of the joint as far as possible and active immediate mobilization.

The results are not equally good in all cases. In certain cases the evolution will be very favorable and function will be preserved, everything going on exactly as in cases of Class A. In other cases the lateral deviation will produce a functional loss of power which will render resection inevitable. The author is not yet able to decide what anatomical conditions may be compatible with conservation and those which demand resection. The problem is a complex one. It seems that the height of the loss of substance is not an essential element. The extent is certainly a matter of importance, but perhaps not the most so. The coexistence of a great wound of the soft parts with destruction of the elements of the joint are not of themselves of as much importance as might be thought. It seems that the factor which plays the essential rôle is the preservation or destruction of the crucial ligaments.

It would appear that whenever the crucial ligaments are present and as much as half of the articular interline is preserved, it is proper to attempt conservation with active mobilization. If the progress is favorable, the patient will, as far as walking is concerned, pass through the same phases as in the preceding case; at first a supporting apparatus, then stiffening spontaneous support of the limb by muscular contraction, finally, retraction of the capsule and of the ligaments.

As to the question, when should a patient who shall have sustained great losses of substance make an attempt at walking? The answer is, as soon as the wound is healed or is in full granulation. If the experiment is not successful and the patient does not find himself able to fix his knee with sufficient firmness, it will be necessary, without being too hasty, to resort to resection.

At the elbow losses of substance of the humerus and the ulna, or the humerus and the radius, may be treated by primary resection, though less frequently than in similar wounds of the knee, for, even if there persists a slight lateral mobility and a certain degree of bending, the function will not be sufficiently interfered with to justify even secondary resection which would not give any better result.

(C) *Fracture with Comminution of One Epiphysis*.—We have to make a distinction here between the elbow and the knee and for each of these joints between the upper and the lower epiphyses.

1. *Knee (a) Upper Epiphysis*.—Here is found most frequently one of the varieties of supracondylar fracture en T, or to be more precise, lesions which though complicated can arrange themselves as a fracture en T. There may be comminutions of the condyle with multiple fragments with descent of the diaphysis so that it is telescoped into a condyle or between the two. Whether the condyle is comminuted or not, such cases require careful removal of splinters and the application of an extension apparatus.

From the beginning the patient should execute limited movements of extension and of flexion. At first difficult and quite limited, they become more facile as consolidation progresses, with, for the time being, a diminution in extension.

As a rule, the later necrosis of certain splinters which were at first adherent, or the appearance of an osteomyelitis, may make necessary several repetitions of such splinter removals.

The result after healing, which is long in being accomplished, will differ according to the extent and variety of the injury. If the two condyles are entirely destroyed or it has been necessary to completely take them away in fragments, a shortening will be inevitable and mobility will be slight; but resection would have made the shortening greater.

In all other hypothetical conditions the situation will be still better. Suppose on one of the condyles, preserved in part, there may have been still preserved a greater part of its articular surface which may have been brought into contact with the diaphysis after it has been pulled up by the extension, there would be presented conditions analogous to those produced by the loss of substance of a condyle without fracture. The mobility can be preserved in very great measure. In such a complication the effect of extension is to replace and hold in place the fragments at first separated from each other, and the interarticular line may be seen to be reconstituted more or less completely.

Cases of this class end usually with the preservation of excellent function. The only difference from the simple removal of fragments is that there is here rather a fracture with great displacement and that before permitting the patient to walk, it is necessary that the fracture should have become consolidated. This takes a time variable according to the character of the infectious phenomena that may complicate the healing, but during this time the mobility can be very well kept up and many

times before the bony foyer has become cicatrized, the patient will be walking with flexion of the knee and without support.

(b) *Lower Epiphysis*.—Comminution of the tibial surface of the knee almost always presents the same anatomical status. There will be a vertical division of the diaphysis into several fragments, in the midst of which the diaphysis will have become impacted, with lateral separation of the fragments. The result of this is a widening of the tibial surface and a lack of correspondence between the articular surfaces.

The wounds which accompany the comminution of the upper segment of the tibia are frequently attended with severe infection and extensive necrosis. Such complications are more frequent and more severe even than in the corresponding lesions of the femur. They consequently prolong treatment.

Aside from the care demanded by the wound, treatment should be directed to re-establishing the correspondence between the two cartilaginous surfaces by bringing the fragments together from side to side. No means contributes better to this result than continuous extension. Extension may be made through screws inserted above the malleoli. The extension should be energetic and should be prolonged until complete consolidation, which is often delayed in consequence of the wound.

By such strong and prolonged extension and by resort to mobilization of the knee, there may be obtained excellent functional results such as resection is incapable of giving.

2. *The Elbow*. (a) *The Upper Epiphysis*.—The shattering of the humeral epiphysis may be so complete that after the fragments have been removed nothing remains of the epiphysis. The condition is equivalent to a partial resection and the function will be good provided the loss of substance does not extend too high.

Often the lesions are less extensive and by the side of a partial shattering of the epiphysis there will remain a segment of the articular part in place. In such a case it is necessary after taking away the fragments, to close the wound and to begin immediately active mobilization. This is possible from the first day and function may be very well preserved. The question of primary resection is never to be entertained here.

(b) *Inferior Epiphysis*.—Comminution here will involve more frequently the olecranon with variable degrees of injury to the radius and ulna. The rule is still more *de rigueur* than for injuries of the humeral segments that primary resection should never be resorted to. After toilet, as usual, removal of fragments and, if possible, complete closure, active mobilization is immediately begun. It is done without difficulty and assures the preservation of the function, even when the loss of substance is considerable and there remains little of cartilaginous surface. The treatment does not involve any apparatus and resolves itself into care of the wound and into the active mobilization. The little lateral deviation is of no importance.

(D) *Comminution of Both Epiphyses.* 1. *Elbow.*—When comminution is complete, the necessary removal of the fragments is equivalent to a resection and there remains only the indication to bring the bony extremities together. But as long as there remains upon the two epiphyses, or upon even one of them, a fragment containing a part of the articular surface, this vestige of the joint should be preserved. Even though the articular vestiges may be minimal, active immediate mobilization will secure astonishing functional restoration. The method may be employed without fear of consequences, since the fixation of the elbow is a secondary element when compared with this method.

2. *The Knee.*—Here it is different. In the knee it is always necessary to first take into consideration fixation.

When the two epiphyses are broken into a large number of fragments, preservation may still be attempted, if a sufficient number of these fragments have remained adherent and are not certainly bound to necrose. To assure one's self, one should take away the splinters manifestly loose and explore the cavity while making extension. One will sometimes be agreeably surprised to find that large fragments regain their place around a simple central loss of substance. If preservation is possible, one would have a member ankylosed, but not shortened. If, on the contrary, callus does not form, the resection may be done secondarily, or even amputation, when the loss of bony substance is too great.

Primary resection or immediate amputation may be resorted to in cases where the first examination shall demonstrate the impossibility of preserving a sufficient number of adherent fragments, cases in which one could not rely upon any consolidation. But apart from such cases of extreme destruction, one may see fractures en T with shattering of one of the condyles to which is added a vertical comminution of the tibial surface as described above. Apart from the comminuted condyle which should be taken away in whole or in part and the fragments of the tibial plateau which often should be removed with the patella, all the rest may be preserved. Continuous extension will bring into line the femoral and the tibial fragments, and the case will be converted into a fracture with loss of substance, but where, on the side of the preserved condyle, the continuity is not interrupted.

One may see this fracture become consolidated, even with some articular mobility. Wherefore, for the injuries of the two epiphyses where the bony pillar can be preserved on one side, primary resection is not to be justified.

It should be added that conditions are changed when a smash, even partial, is complicated by lesions of the popliteal vessels. In such a case immediate amputation must be resorted to.

The conservative treatment thus outlined demands much time and much care. The consolidation may be still attended with many incidents. Infection of the wound has to be combated; necrosis may necessitate

repeated sequestrotomies, etc. But he who does not permit himself to be discouraged by difficulties and who carries on his work with patience will obtain unexpected success.

Presentation of Illustrated Case.—In illustration of the results of the method of treatment which have been outlined in the foregoing section, Doctor Willems presented before the conference a group of patients, 16 in number, in all of whom active immediate mobilization had been employed in various joint injuries of the most diverse character.

The conditions presented by the patients fully justified the claims made by the author in his paper. In some of them the application of mobilization had been resorted to even when purulent arthritis was present, his idea being less the preservation of articular function than the accomplishment of ideal drainage. Mobility, however, is often preserved by such treatment.

The method in such cases comprises wide opening of the joint on one or both sides and active movements of the joint. The movements should be repeated almost without cessation and are to be driven to the maximum of possible excursions.

The author's idea is that such active mobilization produces in a perfect manner articular drainage which no other means can assure. He says that in every case excepting one, he had been able to prevent ankylosis. Up to the present it is not possible to know positively what are the conditions which make the preservation of mobility possible and what are those which render ankylosis inevitable. The virulence of the complicating infection may have something to do with it. It is probable, also, that the closing of the joint as soon as the secretion has been reduced to a minimum may aid in the preservation of mobility, for it is from the time when the joint begins to become dry that in some cases one sees the tendency to ankylosis being developed.

At the conclusion of his discussion he presents the following summary of the rules which are essential to be followed in carrying out his method.

Active mobilization should be begun without any delay and should be carried as far as the patient is in condition to do it. It should be done without interruption, even to the point of fatigue. This mobilization is not painful in the true sense of the word, it is only laborious, and it is necessary to compel the patient to do it, to tease him if he is lacking in courage.

It is never necessary to add passive movements to the active movements with the expectation of hastening the process.

Patients treated by this method never present any serious alteration of their general condition, even during the early febrile period. They never look like those who have been severely infected. They do not fear movements as do those who are immobilized. Even in purulent arthritis it is striking to note that the joint has not that excessive sensibility which an infected joint presents when it is cared for by immobilization.

BOOK REVIEWS

SURGICAL TREATMENT. By JAMES PETER WARBASSE, M.D. Volume II. THE HEAD: THE SPINE: THE NECK: THE THORAX: THE BREAST: THE ABDOMEN. Profusely illustrated. Octavo, cloth, pages 829. W. B. Saunders Co., 1918.

The second volume of Warbasse's book on Surgical Treatment has promptly followed Volume I. The general merits of the treatise were commented upon in the review of the first volume which appeared in the October issue of the *ANNALS OF SURGERY*. The present volume maintains the same standard of thoroughness of treatment, clearness of statement and judicious conservatism in the selection of material which was characteristic of the previous volume. The great cavities of the body, the head and the spinal canal, the thorax and the abdomen, form the subject of this present volume and hence contain the marrow of modern surgery.

The position taken by the author as to the treatment of spontaneous cerebral apoplexy is worthy of quoting. He says:

"The indications for surgical treatment are those of pressure. Medical treatment offers much for the prophylaxis of this disease, but little for its treatment. Surgery can do much for this condition which in every respect is a surgical lesion. The blood coagulates quickly and the hemorrhage is usually ended in a short time. The progressive symptoms which continue are the most gradual changes, such as the development of a zone of œdema due to pressure. It is doubtful if the routine measures to lower the blood pressure in these cases are of value; it is certain that they often do harm. The rational treatment of this condition must be worked out, not by combating the lifesaving mechanism for regulating the systemic blood-pressure, but by relieving the increasing intracranial pressure due to the presence of a foreign body.

"Given a case of spontaneous apoplexy with stupor, or coma, flaccidity of the muscles of one side of the body and high blood pressure in response to intracranial pressure, and the other characteristic signs of hemorrhage in the internal capsule on the side of the brain opposite to that of the paralyzed muscles, the surgeon may expose the brain and relieve the pressure by draining the clot focus. The skull should be opened by trephine or burr just below or above the squamous suture. The dura is opened by crucial incision. The opening should be made sufficiently large to expose the lower end of the fissure of Rolando, the lower ends of the two central convolutions and the fissure of Sylvius. The brain will often show œdema or other local evidence of injection and hemorrhage. If not, it should be entered at the prominent rounded eminence of the lower end of the posterior central convolution just behind the lower end

of the Rolandic fissure and above the Sylvian fissure. A trocar and canula of small size should be entered in a downward and inward direction. It should pass sufficiently above the fissure of Sylvius to avoid the island of Reil. By inserting the instrument in the middle of a convolution no vessels are injured. The apoplectic clot should be encountered within two inches of the surface. A soft roll of rubber tissue to serve as a rubber drainage tube should be inserted through the canula. The clot may be expected to protrude itself through the tube.

"Because of the intracranial pressure there may be some troublesome bulging of the brain after the dura is opened. This may be overcome by elevating the head of the table. Lumbar puncture may be required. As soon as the dura is opened the decompression should show itself in improvement in the patient's general condition. The results of these operations have not been collected sufficiently to place the operation upon a definite surgical basis. Most of them have been done too late when, as a result of laryngeal paralysis, inhalation pneumonia has been engrafted. Others have been attempted when the compression had exhausted the vasoregulator centres. But it can be safely predicted that, as a result of experimental work which is now being done, the operation will become an accepted surgical procedure."

Such a formal suggestion as to surgical interference in cases of the cerebral hemorrhage of apoplexy is certainly up to date surgery and is quite consistent with modern ideas of pathology and treatment. We congratulate the author upon having given the procedure a detailed description and a fixed standing in the surgery of the head.

For the relief of intracranial pressure, as in cases attended with meningeal effusion, the imperative indication to provide drainage is recognized and various methods of meeting the indication are fully described, such as lumbar puncture, tapping of the ventricles and drainage of the subarachnoid spaces at the cerebromedullary angle and lumbar laminectomy. As a whole, the section devoted to the treatment of injuries and diseases of the head is most admirable and comprehensive.

It is not necessary to present any detailed analysis of all the sections of this admirable volume. It maintains fully the standard set in Volume I, and will be accepted by all as a trustworthy guide to the resources of surgery at the present time.

SURGERY IN WAR. By ALFRED J. HULL, F.R.C.S., Lieutenant Colonel, Royal Army Medical Corps, Surgeon British Expeditionary Force, etc. Second edition. Octavo, pages 624, cloth. Philadelphia, P. Blakiston's Son & Co., 1919.

This book is a handbook in reality, as well as in name, suited for the daily use of an army surgeon in active work. In a brief, condensed manner and still with sufficient detail, and with much clearness, the lessons which have impressed themselves upon the practice of British Army Surgeons have

BOOK REVIEWS

been assembled in this book and are published in such a shape as to be convenient for consultation.

The demands of military exigency constitute the primary considerations which present themselves upon every page and control the scope given to every theme. The abrupt termination of active hostilities in November make of it, therefore, a matter of historical interest rather than of immediate importance. As a record of the influence upon surgery which this great war has had, such a book will always be of great interest. Thus, in the treatment of wounds there is a progression stage by stage from the front to the rear, each of which presents special conditions which control the special methods which promise the best results. Thus it is that in the chapter devoted to the treatment of wounds we have first, the first field dressing; next, the treatment of wounds at a casualty clearing station; and third, the methods available at a base hospital. It is most illuminating to follow the progress made in the control of surgical conditions which the increasing duration of combat conditions has developed, as shown by the betterment of the methods of control and methods of prevention, which the last year of the war presented as compared with the first year's record, a résumé of all which this book well presents.

The subjects of tetanus, anærobic infection and gas gangrene naturally receive special consideration, and to each of these subjects a special chapter is devoted.

In the chapter devoted to the subject of shock we recognize the coöperation of Crile. The best methods of overcoming it when already present as the result of wounds and exposure already received, and the methods of its prevention in the course of surgical work which is being contemplated are well summarized.

One of the contributions to practical surgery which the present war has given is that of Trench Feet which also has its own chapter, a subject which now, fortunately, possesses only historical interest.

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THE FORMATION OF BONE

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(From the Stanford University Laboratory of Surgical Pathology)

AFTER Ollier described a cambium layer of the periosteum and ascribed to it a bone-forming function, his views were accepted almost universally until Macewen denied this function, and described the periosteum simply as a limiting membrane. Since Macewen's work was published a heated controversy has been carried on, which has attracted added interest on account of its relation to operations with the bone graft. Each side has presented arguments apparently incontestable, and has backed them with animal experiments.

When such a condition as this exists in medicine, investigation often reveals that each side contains a modicum of truth, that both miss the point, and that neither is exact in definition.

In order to avoid the last error, let us begin by laying down an exact definition of the terms we shall use.

1. *Bone cortex* is the layer of compact bone tissue at the surface of all bones. It is thick in the shafts of the long bones, but tapers off toward their extremities, and is continued under the articular cartilage as a very thin layer. In the shafts it is dense at the periphery, but becomes loose meshed close to the central canal. It is perforated by channels for the entrance of blood-vessels, and contains the longitudinal Haversian systems. It contains marrow throughout, the amount of marrow varying, of course, inversely as the density of the bone. Into it run prolongations of the periosteum, which bind the two tissues together. In other words, the cortex contains marrow and "periosteum."

2. *Marrow*.—"The soft fatty substance filling the medullary cavities and cancellous extremities of the long bones" (Stedman). This definition manifestly is not exact enough, for the marrow may consist in certain circumstances of little else but fibrous tissue, and the long bones do not enjoy a monopoly of marrow. Lippincott's dictionary defines marrow as "The fatty, oleaginous substance in the cavities of long cylindrical bones, and in the cavities of cancellous tissue." This makes the fatty substance the chief constituent of marrow, and is not exact enough for our purpose. Lymphoid marrow and fibrous marrow contain little fat, and a fibrous reticulum is a part of all marrow.

Dorland defines marrow as: "The soft material that fills most of the cavities and cancelli of the bone. It is made up of a mesh work of connective tissue containing branching connective tissue corpuscles, the meshes of the mesh work being filled with marrow cells, which consist variously of fat cells, large nucleated cells, or myelocytes, and multinucleated giant cells called myeloplaxes." This is a fairly accurate description of the constituents of most marrow. The first part of the definition should read "all" instead of "most." The mesh-work may be filled with the cells described or it may not. If it is not, the tissue is marrow, none the less.

The Century dictionary defines marrow as "the soft tissue found in the interior of bones, both in the cylindrical hollow of the long bones, and in the hollows of the cancellated bones."

Marrow is one of the most changeable tissues in the body. It is generally described as being of three varieties, lymphoid, fatty and "myxomatous." Whichever it is, it is always marrow. Its situation, not its composition, determines its name. Marrow is the soft tissue within the bone—all soft tissue within the bone. We may find in the marrow typical "marrow" cells, blood cells in various stages of formation, connective tissue, "osteoblasts," "osteoclasts," blood-vessels, fat. Wherever there is bone there is marrow, in the cortex, in cancellous bone, and in the central canal.

Typical marrow tissue is found not only deep in the cortex, but it pockets immediately under the periosteum. These pockets, as far as I know, have never been described. They are not numerous, but in examining a large number of slides, one occasionally sees them in the region of the joints.¹

We have defined marrow as the soft tissue *within* the bones, and the lexicographers also define it as a tissue within the bones. This typical "marrow" tissue then cannot be marrow. It certainly is not bone. It must be periosteum, for it is outside the bone.

3. *Periosteum*.—This is the tissue which covers all bone, except at the joint surface. Its structure has been variously described. The question can be determined not by animal experimentation or clinical phenomena, but only by looking at the tissue under the microscope. If we do this we see that the periosteum consists mostly of fibrous connective tissue. Occasionally it consists of fibro-cartilage or hyaline cartilage. Sometimes one sees here and there a well-defined cellular layer, but generally one does not, and if one does not see a cellular layer, it is not there. The cellular layer is said to be more prominent in the bones of the young than in those of the adult.

The periosteum, as has been said, sends prolongations into the cortex, but by our definition they must become marrow as soon as they enter the bone. They certainly cannot be periosteum, for periosteum is the tissue outside the bone.

We have, then, outside the cortex typical marrow tissue, which is periosteum, and within the cortex typical periosteal tissue, which is marrow.

¹ Ely and Cowan: Bone and Joint Studies I. Stanford University, California. Published by the University, 1916.

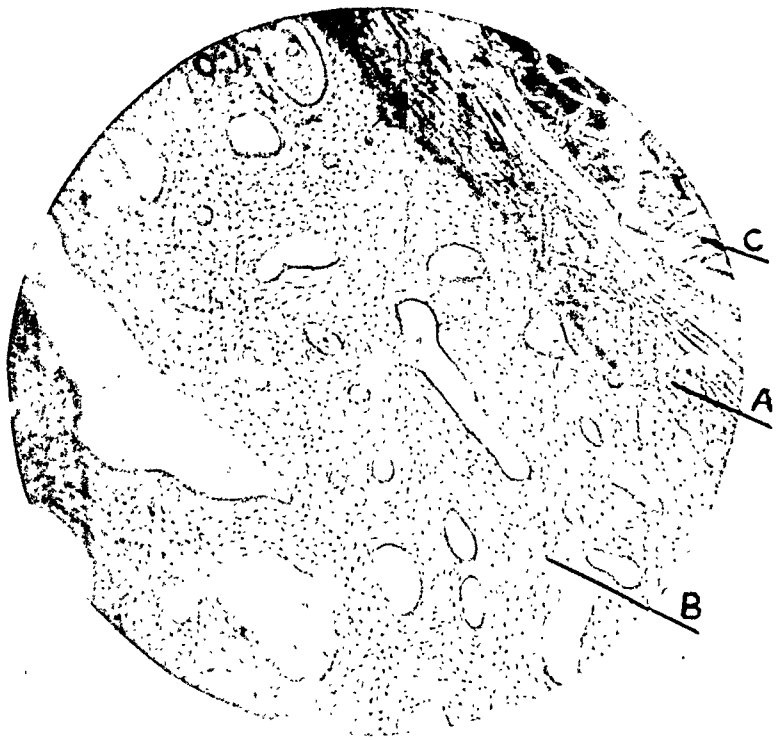


FIG. 1.—Low-power photomicrograph of lower metaphysis of adult femur. A, periosteum; B, bone; C, muscle.



FIG. 2.—Low-power photomicrograph of bone showing narrow pockets (P) from human clavicle near the sterno-clavicular joint.

FIG. 3a



FIG. 3b



FIG. 3 a and b.—Photomicrographs of marrow pockets, also from a clavicle.

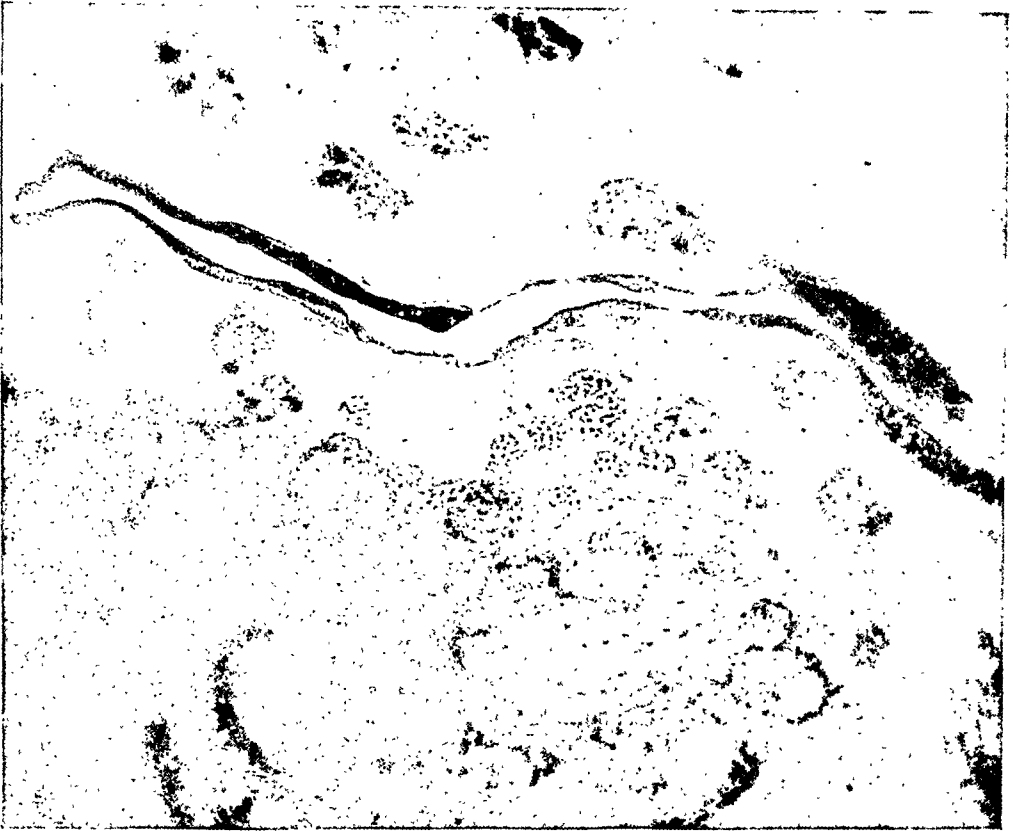


FIG. 4.—Photomicrograph of hyaline cartilage on the outside of a clavicle.

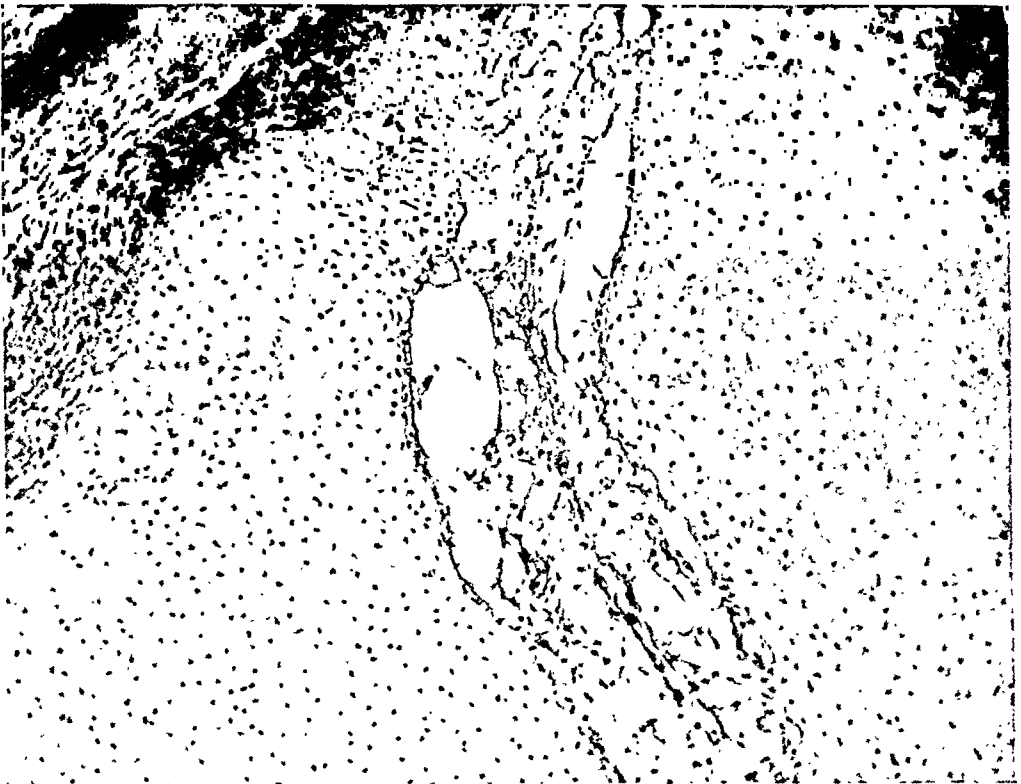


FIG. 5.—High-power photomicrograph showing vessels pushing their way into the cartilage; from the talus of a four-month fetus.

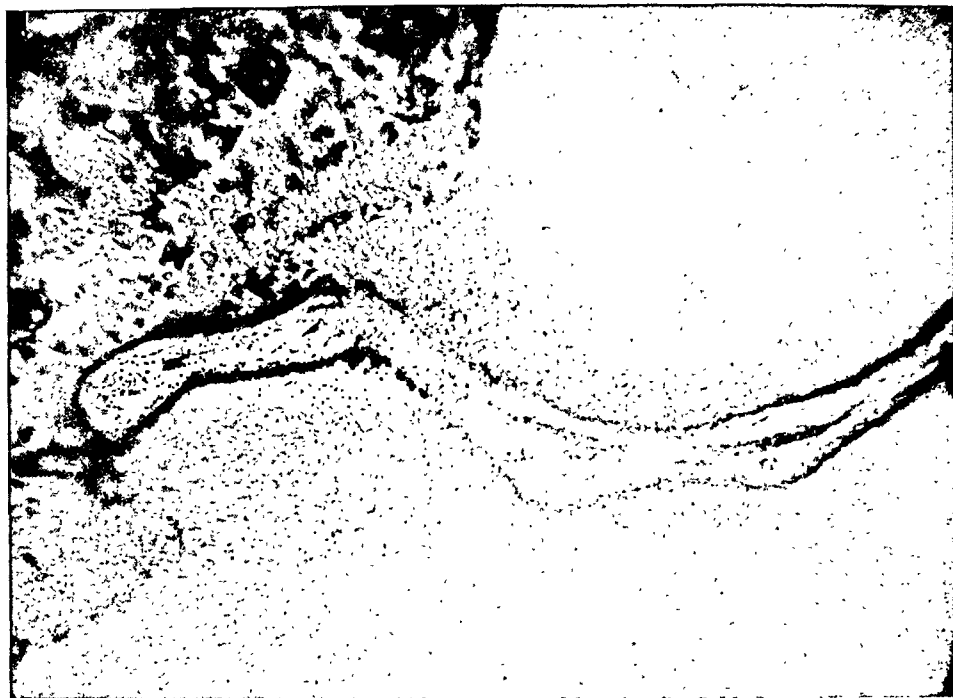


FIG. 6.—Lower power photomicrograph of intracartilaginous ossification, showing blood-vessels running through the cartilage to the bone nucleus; from the lower femoral epiphysis of a foetus at term.

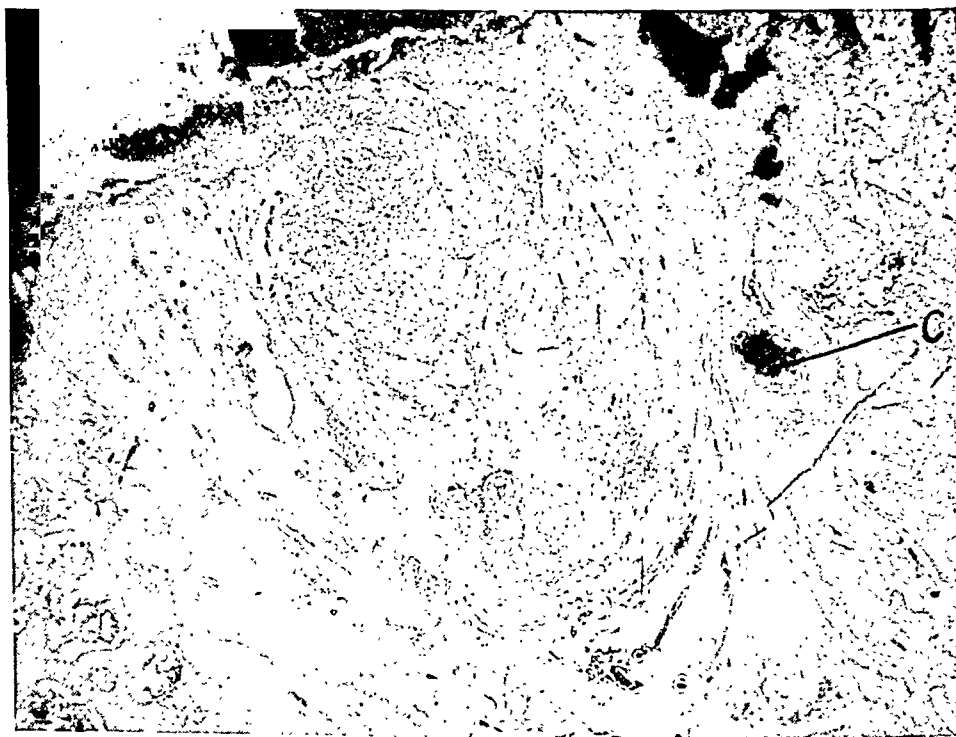


FIG. 7.—Bone formation around an old tuberculous focus immediately under the articular cartilage of the lower end of the femur. C, island of cartilage among the bone trabeculae.

THE FORMATION OF BONE

Let us turn now to what we know about bone formation, and see what we can gather from facts that we all accept.

1. Intracartilaginous bone formation begins with the pushing of blood-vessels into the cylinder of cartilage (in a long bone). Around these blood-vessels calcification and ossification take place. A similar process takes place later within the epiphysis. Here, then, is *bone formation without marrow or periosteum*.

2. Bone is formed without marrow or periosteum in the walls of the aorta, and in the kidneys of laboratory animals whose renal vessels have been tied off.²

3. Bone tissue is formed out of cartilage or fibrous tissue, within the bones, without the aid of the periosteum.

4. Bone is formed in fibrous tissue—intramembranous ossification, before any marrow is present.

5. Bone is formed on the outside of the cortex, beneath the periosteum.

6. Bone is formed in the periosteum, not alone on the cortex under it. This is not generally known. I show herewith a photomicrograph of new bone formation in the periosteum, from the tibia of a dog fourteen days after the resection of the knee in the immediate vicinity.

7. New bone is often formed in necrotic lymph nodes and in the kidneys.

8. Bone contacted with bone and enjoying a functional use, persists. Bone buried in the soft tissues, without function, slowly disappears.

If we sum up our facts we find that only three things are necessary for bone formation:

1. Blood-vessels.

2. Either a loose meshed fibrous tissue, or a homogeneous (cartilage matrix), or a granular or a necrotic material.

3. A stimulus, physiological or pathological, as the case may be. It is this stimulus that causes the blood-vessels to push into the cylinder of cartilage in the first place, and that causes the bone production in the aorta. This is perhaps vague, but we can go no farther at present.

It is seen, therefore, that neither periosteum nor marrow is necessary for bone formation, and that neither of them "forms" bone, in the proper meaning of the word. In each tissue the conditions are right for bone formation. The materials are there, and, given the stimulus, physiological or pathological, bone will be manufactured out of the fibrous tissue of the periosteum, or out of the fibrous or cartilaginous tissue in the marrow. The presence of bone is to a certain extent a stimulus for further bone formation. The true marrow cells, the characteristic marrow cells, probably have no function in bone building whatever.

The *osteoblast* is the bone-building cell, if the present theory of bone formation, the neoplastic theory, is correct. What is an osteoblast, and

²Liek: Zur Frage der heteroplastischen Knochenbildung. Archiv für klinische Chirurgie, 1906, lxxx, 279.

how can it be distinguished? It is generally thought to be a mesoblastic cell, but Geddes³ says it wanders in from the epiblast. Moschcowitz⁴ says it is simply an endothelial cell from the lining of the blood-vessels.

The osteoblast has no physical characteristics by which we can distinguish it from other cells, as has, for instance, the eosinophile, the myeloplax or the polymorphonuclear. It is described as a small, round or polyhedral cell with deeply staining nucleus seen on the surface of the bone trabeculæ or bone lamellæ. Its situation, in other words, is its distinguishing mark, like the man with an apron standing behind the counter in a butcher's shop. We recognize him as a butcher merely because we see him standing there. When we see these small cells lining the trabeculæ we say that "productive osteitis" is going on, and when we see giant cells in Howship's lacunæ we recognize "rarefying osteitis." This is only relatively accurate. The second is probably always true, but not the first. In certain inflammations in bone, notably tuberculosis and acute suppurative osteomyelitis, where we know from the X-ray picture and from microscopic examination that the bone is being absorbed, typical "osteoblasts" can be seen lining the trabeculæ. By all the accepted definitions of these cells new bone should be forming very rapidly, but we know it is not.

All that we can say about the osteoblast is that there is probably such a cell, of unknown derivation, and that possibly the same cell which can build up bone can also tear it down. When we see these cells edging the trabeculæ in bone that we know is building up, let us by all means call them osteoblasts, but when we see similar cells in the same situation in bone that we know is being torn down, let us not close our minds to the actual state of affairs and call the process productive osteitis.

The opinion I have derived from studying my bone slides is that when nature wishes to rearrange the architecture of bones, as after resections or fractures, or on the inside of the cortex in normal growth, she does it with the so-called osteoclasts. When, however, the bone is being absorbed as the result of an inflammatory process in the marrow, the active factor is a small cell, not to be distinguished from the typical osteoblast, and arranged in a row along the trabeculæ just like the latter.

The bone marrow is one of the most active, interesting and complex tissues in the body. We still have much to learn about it. Our knowledge will not increase rapidly if we form theories to start with, and then try to confirm them by animal experimentation. If new bone forms on transplanted periosteum in animal experiments, we are not justified in concluding that the periosteum "forms" bone, any more than we are justified in concluding that iron forms calcium oxalate because a hairpin in the bladder

³ Geddes: Origin of the Osteoblast and Osteoclast, *Journal of Anatomy and Physiology*, 1912, xlvii, 159.

⁴ Moschcowitz: The Relation of Angiogenesis to Ossification, *Johns Hopkins Hospital Bulletin*, 1916, xxvii, 71.

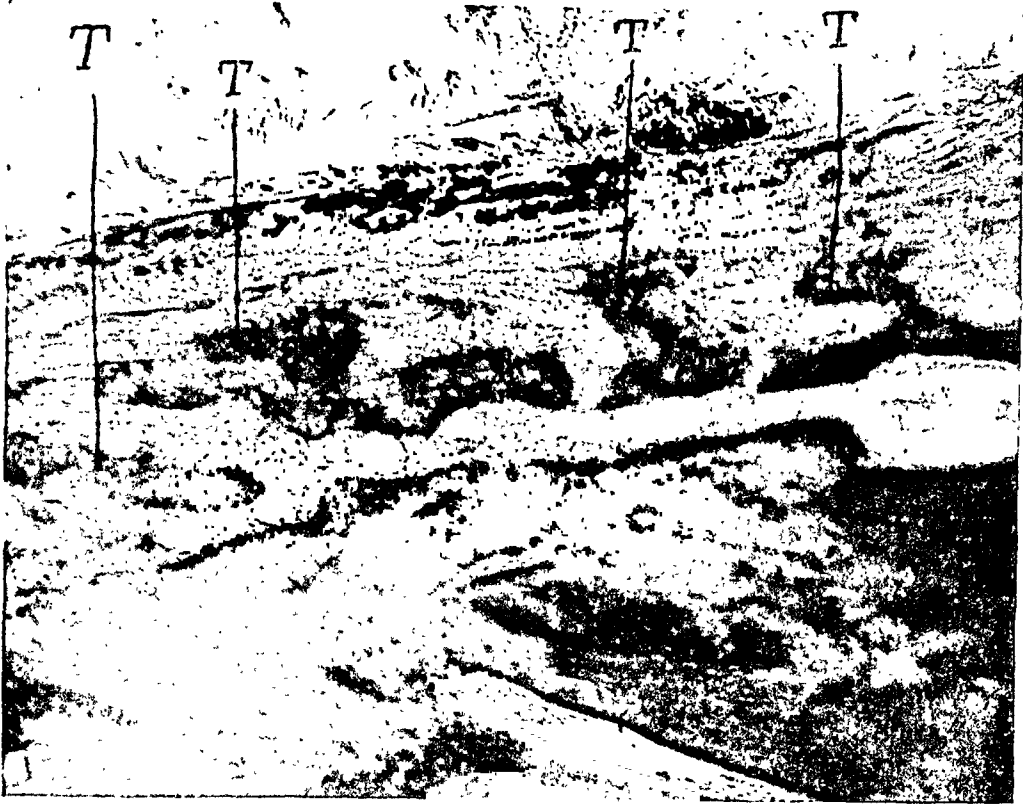


FIG. 8.—Photomicrograph showing new bone formation in the periosteum, from the tibia of a dog fourteen days after knee-joint resection. *T*, new trabeculae.



FIG. 9.—Photomicrograph of a section of bone from a case of acute suppurative arthritis. *T*, trabeculae; *C*, colony of pus cocci. This illustration was published five years ago as showing "productive osteitis." The bone is being rapidly absorbed, many of the trabeculae are dead, yet on the trabeculae can be seen many cells which present the classical appearance of osteoblasts. Zeiss apochromatic, 16 mm. ocular 4. Tube length, 47 cm.

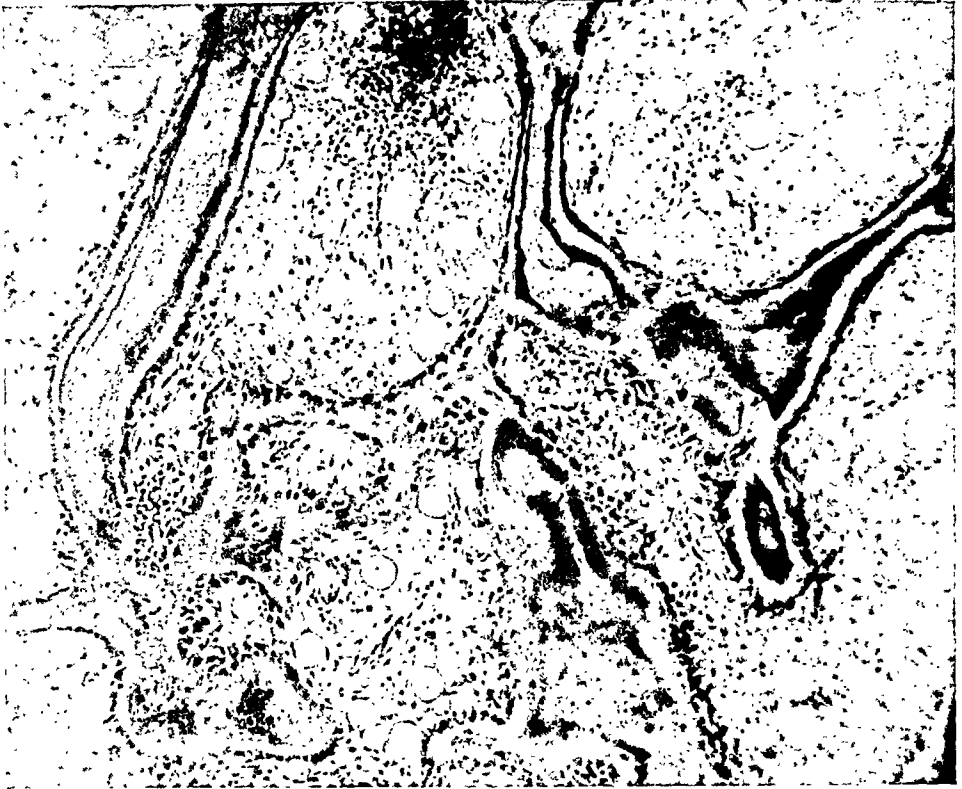


FIG. 10.—Photomicrograph of a section from a case of bone tuberculosis. The bone is being torn down, but the trabeculae show in their borders what we are wont to call osteoblasts.

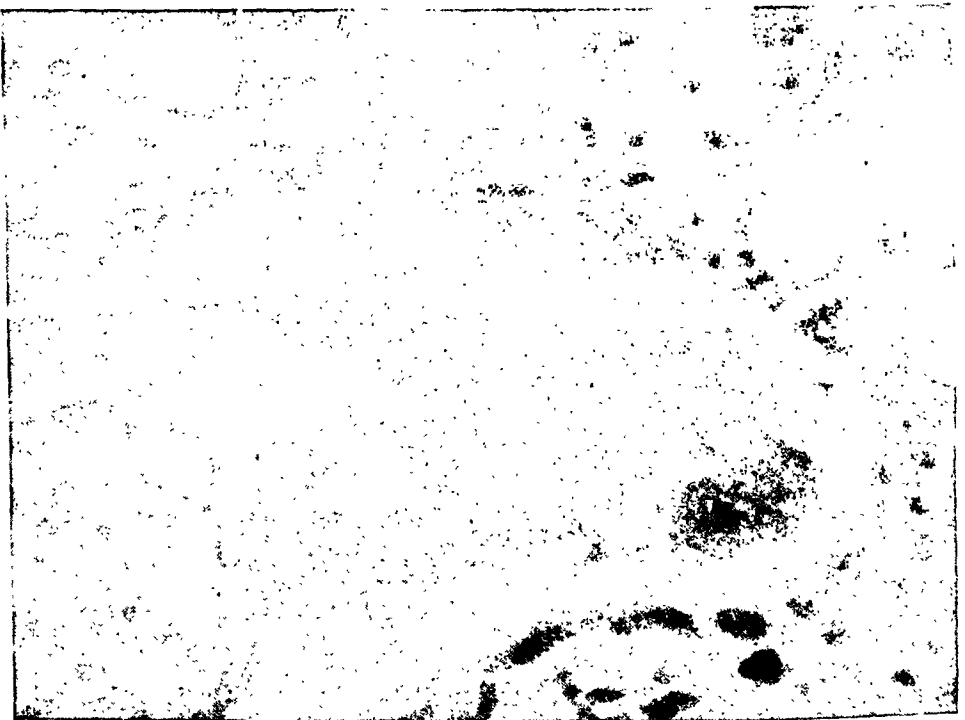


FIG. 11.—High-power photomicrograph of some of these typical "osteoblasts."

THE FORMATION OF BONE

becomes encrusted with it. The fibrous tissue of the periosteum is the same as other fibrous tissue. If there are osteoblasts under it, they will form bone, as will any other osteoblasts.

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THE REPAIR OF CRANIAL DEFECTS *

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THE problem of repairing defects in the cranium has been brought prominently before the surgical profession by the war. Hitherto the number of cases coming under the notice of any one surgeon was very small, so that slight opportunity was afforded for the development of the best means of dealing with the subject. Moreover, in the pre-war days trephining was comparatively rare and the small opening left was quickly filled in by dense fibrous tissue which was almost as secure as the bony covering. To-day trephining is common and in the great majority of cases the hiatus is of considerable size and the cause of various disturbances.

Before attempting to remedy a defect in the skull it is important to make a very thorough examination of the patient with especial reference to the nervous system. Many of these men suffer in a greater or less degree from functional disturbances and these may or may not be relieved by the surgical procedure. Some are so mentally deficient that it would be unjustifiable to interfere. Again there may be some deep-seated lesion which could not be expected to be benefited by a restoration of the protective covering. Of course, if a foreign body be present it should be removed if at all feasible, but it must be kept fairly in mind exactly what is to be expected from the operation. We replace a yielding scar by a non-yielding substance and at the same time release the brain beneath the hiatus from the edges of the osseous opening and smooth down the dural edge. Consequently only those symptoms which can reasonably have a causal relationship with the pathological conditions remedied can be expected to be cured or relieved.

The symptoms usually complained of are headache and dizziness when suddenly stooping or turning suddenly. In addition there may be a feeling of fear lest the head be injured, lack of interest in their surroundings, inability to stand noise, blurring of vision and epileptiform attacks. The physical signs are visible pulsation and impulse on coughing.

Under such conditions the delicate structure of the brain is being subjected to frequent if slight injury, and unless contraindicated by some general disease like advanced diabetes or Bright's disease, calls for surgical intervention. Furthermore, it is quite proper to advise operation in those instances where the patient complains of nothing whatever, merely with the object of ridding him of a disfiguring deformity. Having determined that an operation should be performed it remains to be decided when and how.

* Read before the December meeting of the Academy of Medicine of Toronto.

THE REPAIR OF CRANIAL DEFECTS

Most surgeons are agreed that at least three months should elapse after the healing of the wound before interfering, although Woodroffe operates much earlier and so far has had no trouble. The great danger in early operation is the possibility of setting free latent infection; Harrison applies radiant heat to the scar previous to operating. If latent sepsis be present it is shown by inflammation in the cicatricial tissue which sometimes breaks down. In any case, it is well to bear in mind that the longer the period of suppuration the longer should we wait before attempting to repair the defect by any grafting operation.

The methods adopted to close cranial defects are now quite numerous and may be classed as follows: (1) bone grafts, (2) metallic plates, (3) cartilaginous grafts. Considering these in detail we find that bone grafts have been obtained and utilized in a variety of ways. Mayet (*Bull. acad. de Med.*, 1916) described an operation by means of which the external table with its intact pericranium was detached from the inner table over an adjoining and suitable area and swung round on a pedicle of pericranium in such a way that the outer surface of the graft came in contact with the brain. It was sutured in place and the scalp closed.

Le Fur in the *Press Med.*, 1918, describes a modification of the former operation which he calls dedoubling. Adjoining the opening a suitable piece of the external table and its pericranium is mobilized but left attached by a strip of the latter along the margin of the defect. It is then turned back in place. He reports thirty-seven cases, in six of which the breach was seven cm. in diameter. In no case was there exaggeration of the symptoms and nearly all were improved. He had one death from infection in the third week.

Autogenous tibial grafts are favored by a number of workers. Morrison in the *British Journal of Surgery*, January, 1917, reports twenty-one cases with no deaths. After turning down a horseshoe flap which includes the aponeurosis the pericranium is divided one-quarter of an inch from the margin of the hiatus and the outer table removed for half an inch to make a shelf for the graft. This is cut from the inner surface of the tibia, taking care to leave the crest as his second patient sustained a fracture of the leg which he attributed to his having failed to leave the anterior border. The periosteum is left longer than the bone to allow of its easy suture to the pericranium. If the area to be grafted is convex as is usual the graft may be bent by saw cuts which leave the periosteum intact. The graft is placed with its deeper surface against the scar in the brain. His first operation, owing to the large size of the hole, had to be done in two stages. At the second operation, four months later, there was firm bony union, and no excess of callus. He draws attention to the fact that in all his cases there was tenderness in the grafted area for about six or eight weeks. Instead of the tibia some surgeons use the ribs. Brown, in the *Med. Journal of Australia*, 1917, reports thirteen cases in which the defect was closed by this method. The rib is removed in

such a way that the periosteum on the outer surface is left attached while the deeper portion remains *in situ*. The rib is then split into outer and inner halves, and the former is fitted into the defect in such a way that the membrane covered surface is outermost. The advantage claimed over tibial graft is that they are more easily obtained, and the ribs have a rounded contour.

In a few instances other autoplasic bone grafts have been used. Monclaire made a graft from the great trochanter while Leclerc resected a portion of the scapula. Heterogeneous bone grafts have been employed on a few occasions, Macewen and Richard having each utilized the bones of a dog, while in Lexer's clinic the horns of cows have served the purpose.

Of the methods thus far dealt with the bone graft has been taken from a living subject. In *Presse Med.*, 1917, Sicard Dambrim and Roger describe the operation which they perform. A piece of skull of suitable size is removed from the cadaver. It is perforated by small holes 0.5 cm. apart, and scraped on the under surface till the diploic tissue is seen, the resultant thickness being $\frac{1}{2}$ cm. The edges are bevelled. It is then carefully sterilized but not decalcified and tested for bacterial growth before using. After freeing the flap the pericranium is incised 1 cm. all around the opening and stripped up in both directions. The inner strip left attached to the edge of the opening is then thrown over so as to lie against the brain scar. The graft is inserted between the outer strip of pericranium and the bone. They admit having had trouble with their first operation owing to faulty technic, but in the last forty-two the results have been uniformly successful. In one case they had occasion to reopen the wound four months later, when they found the grafts well fixed in the original position and with the perforations in the graft choked with fibrous tissue.

Metallic plates have had an extensive use during the war.

Mitchell, in the *British Journal of Surgery*, July, 1917, reports six cases treated by perforated silver plates of a thickness rather less than the ordinary calling card. The holes are one-eighth of an inch in diameter placed as close as possible. The plates are placed beneath the pericranium and sutured with catgut. None of his cases suppurated, and he shows one after an interval of five months.

Estor, in *Bull. et mém. Soc. de chir.*, 1915, reports eleven cases treated by gold plates, one-quarter of mm. in thickness. Projections along the edges are left which fit into the diploe. One case died from abscess formation.

Noon, in *British Medical Journal*, March, 1917, reports three more cases treated by gold plates. All were successful, while Duval, in *Bull. et mém. Soc. de chir.*, 1915, gives details of three cases treated in like manner, but substituting aluminum for the gold which was impossible to obtain.

Cartilaginous grafts were introduced by Morestin of Paris. In his

THE REPAIR OF CRANIAL DEFECTS

first operation in which there was a large defect in the frontal region he used a homogeneous graft, while in the second the cartilage was taken from the patient himself. Both were equally successful. Since that time a large number of cranial defects have been treated by autogenous cartilaginous grafts and series of cases have been reported by Villandre, Gosset, Rouhier, Woodroffe, Gilmour and others. The operation as performed in the service of Colonel Primrose at the Toronto General Hospital is as follows:

After a tight-fitting layer of gauze has been placed over the prepared head, and an elastic tourniquet is tied around the base of the skull in the usual way, a flap of skin including the epicranial aponeurosis is turned down, a procedure which in certain instances is difficult owing to the close adhesion between the scalp scar and brain. The margin of the hiatus is then identified and the pericranium is incised all around it at a distance of a quarter of an inch. The pericranium is stripped up in both directions. The inner strip is freed to the margin and then the scar tissue adherent to the edge of the defect is likewise pushed inwards with a periosteal elevator until the dura is exposed. The latter is likewise freed for about a quarter of an inch, so as to examine for thickening or spicules which might cause injury to the underlying cerebral tissues. Any such abnormality is immediately dealt with. By means of an electrically driven burr the outer table is removed for a distance of about three-eighths of an inch all around the opening, the object being to make a shelf upon which to place the graft and at the same time set free osteoblasts. When the bleeding has all been controlled the wound is packed with gauze, wrung out of hot saline, and while the assistant keeps up a moderate pressure the surgeon proceeds with the cutting of the grafts. A vertical incision about six inches long is made two inches from the mid-lines, splitting the fibres of the rectus abdominis. The muscle is retracted and the cartilage of the sixth, seventh and eighth ribs exposed. If a larger graft is required the incision can be extended in either direction. Bearing in mind the size of the hiatus a suitable graft consisting of two-thirds of the cartilages is removed. This is the most difficult part of the operation, for the graft must be uniform in thickness so as not to bend readily. Then the graft should be removed in one piece. When the opening is 2 inches by $1\frac{1}{2}$ inches there should be no difficulty in closing it with one piece, but when larger the graft is roughly Y shaped, and this must be so placed that the three corners rest upon the skull. Unless the graft has a firm support the end result will be disappointing in that the bulging on coughing remains. If properly done there will be no impulse. The grafts are immediately placed in warm saline, and when satisfied that sufficient cartilage has been procured an assistant closes the chest wound while the surgeon places the graft in position. Since the grafts take on a rounded shape with the convexity towards the cut surface, the smooth perichondrial side is placed next the brain. They

are layed on the prepared shelf, and beneath the pericranium which is stitched to the cartilage by means of a chromic catgut. In a large defect it will be found impossible to fill the defect with one graft, so that additional pieces are suitably placed and sutured to the pericranium and the cartilage of the main graft. When all hemorrhage has been controlled the flap is stitched in place with silkworm gut, a small drain is inserted and the wound dressed with a fairly tight bandage. The tube is removed after forty-eight hours, and the stitches in ten days.

The following is a brief summary of the cases so far dealt with in the clinic:

CASE I.—H. S., age twenty-two, R. A. F. Hit by propeller November 29, 1917, at Fort Worth, Texas, and was unconscious for three weeks. Immediate decompression. Left hospital in January, 1918.

Complaint.—On admission March 2, 1918, dizziness on turning quickly. Headache in left temporal and occipital region, poor memory for recent events, deafness and noises in right ear.

Examination.—Well-developed man. There is a defect in the left frontoparietal region, measuring $2\frac{1}{2}$ inches by $\frac{3}{4}$ inch. It pulsates and has an impulse on coughing and is depressed. On April 12th Colonel Primrose closed the defect by autoplatic cartilage graft taken from the right side, six separate pieces having been utilized. The convalescence was uneventful, stitches being removed by the 22d, and the wound was clean—no impulse on coughing. Then, on May 15, he started to complain of headache again, and chiefly occipital. Given three months' leave of absence, and was readmitted again in September complaining of headache (left occipital). The great occipital nerve was injected with alcohol on this occasion, but the relief was only temporary. It was observed now that the grafted area was not as firm as it was, especially in the anterior part, where there was some bulging when he coughed.

CASE II.—T. Y., aged twenty-four years, admitted May 16, 1918, discharged August 23, 1918. Wounded November, 1917, in two places, one over frontal bone above right eye, and extending into hair, being 2 inches by 1 inch, the other in the occipitoparietal region on right side about $1\frac{1}{2}$ inches above right ear, and 1 inch square. Was unconscious three days.

Complaint.—Constant dull headache over frontal area. Has had two fits since returning. Has never been dizzy, but vision is blurred in left eye.

Operation (May 22, 1918).—Colonel Primrose. Marked thickening of margin, laterally. Dura opened at one point and cerebrospinal fluid escaped.

On June 2d, patient had a convulsion, otherwise convalescence normal.

Operation on Second Defect.—Colonel Primrose. July 12, 1918. Dura again opened in one place, and a sudden convulsive movement of the leg occurred during the manipulation. The next day he had a con-

THE REPAIR OF CRANIAL DEFECTS

vulsion which was relieved by removing dressing. On 16th there was considerable serous discharge and the next day purulent culture showed streptococcic infection. Scar in centre and flap sloughed on 24th, and a suture of catgut came away. On May 18, 1918, the scalp was dry, and patient transferred to Whitby. At that time patient felt stronger and had lost his headache.

CASE III.—W. F., aged twenty years, admitted May 22, 1918, discharged June 27, 1918. Wounded October, 1917; unconscious for only a few hours following wound. Never headache, loss of memory, or other disturbances, only weakness of hand and leg for two months after wound. Large hiatus in left parieto-occipital region, 3 inches by $1\frac{1}{2}$ inches. Impulse on coughing present and pulsation.

Operation (May 29, 1918).—Colonel Primrose. In this instance scar (central part) was excised. Scar very adherent in places, so dura was opened at the post margin. Bony rim was rough and a spicule was found to press inwards. Some tension on flaps when sewn.

Slight pulsation on coughing remains, and has had some headache since the operation.

CASE IV.—F. C., aged twenty-six years, admitted July 5, 1918, discharged August 30, 1918. Shrapnel wound, April 9, 1917, of left frontoparietal region. Immediately after the injury he had a fit and was paralyzed on the left side. Was unconscious for three weeks. A fortnight later the paralysis cleared up on the left side and the right side was paralyzed. He doesn't know how long they lasted. The hiatus is $2\frac{1}{2}$ inches anterior posterior and 2 inches in a vertical direction. It is markedly depressed, and pulsates on coughing or stooping. Scar is densely adherent to the tissues beneath. It is tender on pressure.

Fits have been very frequent ever since. Sometimes as many as three a day. Has an aura, which consists of twitching of fingers and thumb of right hand and a buzzing in the ear.

Symptoms.—Headache, chiefly frontal. Difficulty in breathing. Difficulty of speech. Loss of power to read. Is learning from first reader.

Operation (July 16, 1918).—Major Wilson. Scar very adherent and difficult to free from brain. Wound healed by first intention. Took three fits through the night, then only one more while in hospital. August 30th note says scar firm. When last seen there was an impulse in the anterior part of wound.

CASE V.—A. M., aged twenty-four years, admitted August 1, 1918, discharged September 27, 1918. Wounded November, 1917, the missile entering the parietal region and coming out in the occipital. Did not lose consciousness, but when he tried to walk found the right arm and leg very weak. Face was never paralyzed. Later at dressing station lost consciousness—lasting for ten days. At present the movement of the right ankle and foot is very poor, and he has homonymous hemianopsia.

Complaint.—Dizzy spells and faintness. Loss of memory for recent events. Dimness of vision. Weakness of right side of body.

Operation.—The parietal defect had been closed by Lieutenant-Colonel Gilmour at Orpington, April 17, by a tibial graft.

Operation on the occipital defect, which was $1\frac{1}{4}$ inches by 1 inch, was performed by Lieutenant-Colonel Gilmour on August 9th, the pieces of cartilage being placed over in a trellis-like manner, as advised by Villandre.

CASE VI.—A. W., aged twenty-eight years, admitted May 29, 1918, discharged July 18, 1918. Hit by shrapnel casing April 22, 1917, unconscious for eight hours.

Complaint.—(1) Dizziness when bending over. (2) Left frontal and temporal headache increased by sunlight. (3) Inability to open mouth.

Trephining (May 10).—F. B. removed from brain together with small piece of bone. Day following operation his left arm and leg were powerless. Discharged pus until September, 1917. Since October, 1917, headache has been getting worse. Dizziness disappeared from September, 1917, to May, 1918, but is getting bad again. Lost memory for a month after operation. Jaw opens half way.

Status Præsens.—No paralysis. There is a depressed scar in the hiatus which extends from the exterior angular process of the frontal bone to just above the exterior auditory meatus and reaching $1\frac{1}{2}$ inches above the zygoma on the left side. There was no pulsation but slight bulging on coughing.

Operation (June 12, 1918).—Major Wilson. In this case the temporal muscle was firmly adherent to the scar over brain and explained why he could not open his mouth properly. Hiatus closed with cartilage in one piece, the lower portion tucked in under the muscle to prevent adhesions again. The day following the operation patient was advised to keep the jaw moving and he could open it freely. This led, however, to considerable oozing of blood, which, by the sixteenth, was serous in character, but by the eighteenth, or six days after operation, was definite purulent and culture showed a streptococcic infection. On July 1st a small piece of cartilage came away and shortly after the wound was healed and firm.

His dizziness disappeared, and so did the headache except for an occasional slight attack. The jaw movement was increased about 10 per cent.

CASE VII.—D. S., aged twenty-four years, admitted May 11, 1918, discharged June 25, 1918. Hit by shrapnel May, 1917. Unconscious three days. Shrapnel removed at base hospital. In bed four months. Defect to right of midline in the frontal bone over right eyebrow and extending into hair. There is marked pulsation and an impulse on coughing.

Complaint.—Dizziness and headache, memory is good.

Operation.—Major Gaby. On May 21st dura opened in this instance and considerable cerebrospinal fluid escaped. In separating dura from the edge of hole some spicules were found protruding.

THE REPAIR OF CRANIAL DEFECTS

These were removed. June 7, 1918, patient up in chair and no headache or dizziness.

CASE VIII.—W. C., aged thirty years, admitted May 15, 1918, discharged June 27, 1918. Shrapnel wound, May 22, 1916. Wound remained open until July 12, 1916.

Status Præsens.—A large defect in the right frontoparietal region of an irregular shape. It pulsates freely on coughing. There was ptosis of right eye and total blindness on that side.

Complaint.—(1) Buzzy noise in right ear. (2) Dizziness. (3) Right side headache. Attacks of tingling sensation in both hands and extending up the arms when excited. Twelve in number and consciousness is lost.

Operation (May 23).—Lieutenant-Colonel Gilmour. Transplant in one piece. Slight pulsation remained and headache was still complained of.

CASE IX.—W. A., aged twenty-nine years, admitted November, 1917. Unconscious at once, lasting three hours. Metal fragment removed at C. C. S. Paralysis of entire left side.

Status Præsens.—Healthy looking man. Memory for recent events poor. Headache in parietal region since injury. Dizzy spells on stooping or when walking. Headache. Fits, the first occurring in February last. Once a month about June. Has an aura of choking sensation in throat some minutes before nausea. Hiatus about the size of half dollar in left parietal bone over prominence. He has a chronic suppurative otitis media of left ear. On September 2d he had a fit.

Operation (Lieutenant-Colonel Gilmour).—The cartilage being placed between a lattice work of chromic gut. Wound healed first intention and he was discharged on October 17, 1918. No note as to improvement.

CASE X.—J. T., aged twenty-six years, admitted September 19, 1918, discharged November 27, 1918. Wounded August 15, 1917. Had aphasia and right hemiplegia following injury.

Status Præsens.—Patient is a healthy looking man, but there is a pulsating defect over the left parietal region. The scar is very adherent.

Complaint.—(1) Headaches and dizziness. (2) Weakness of right side. (3) Deficient memory and speech. (4) Fits.

First fit occurred in March, 1918—that is, about seven months after being wounded. Has had them frequently since. They commence in the front, but only occasionally is consciousness lost.

Operation (September 23, 1918).—Lieutenant-Colonel Gilmour. In this the scar was excised, cartilage was placed between lattice work of chromic gut.

September 24, 1918, patient was very irrational, and had one fit.

The next note on the history shows that both the scalp and chest wounds are sloughing with considerable discharge of pus.

On November 4 the cartilage grafts came away together with a lot of suture material.

By November 24 the scalp was healed and the interesting note was made that pulsation was invisible, although it still bulged on coughing.

CASE XI.—J. W. M., aged twenty-two years, admitted November 12, 1918, discharged November 30, 1918. Wounded October, 1917. Had a silver plate inserted in England, but the wound became infected, and the scalp never healed over, so was later taken out after six months. Completely healed since June.

Status Præsens.—There is an irregular defect over the right fronto-parietal region, which pulsates freely. Headache with sharp shooting pains over the left frontal region, dizziness on becoming heated.

Operation (November 16, 1918).—Colonel Primrose. In this instance the central scar was excised and the scalp retracted. The next night he had a slight seizure, so the bandages were loosened.

On November 20, 1918, the wound firmly healed. No impulse on coughing. Has had no headache since.

CASE XII.—C. R. F., admitted November 8, 1918; still in hospital. Wounded in right knee on October 26, 1917. The thigh was amputated. Three weeks later a metastatic abscess developed in the cranium which resulted in a sequestrum two inches by three inches, which was removed on the 21st of January, 1918. The scalp has been healed since May last.

Status Præsens.—The defect over the mid-parietal region on the left side is nearly $\frac{3}{4}$ inch. There is slight pulsation on coughing, and the scar is firm.

Complaint.—Headaches which come on at various intervals, often goes three or four days without them, hot sun aggravates them, dizzy attacks about once a week, always at night and usually after going to bed, sensation of bed upsetting.

Operation (November 20, 1918).—Captain Shenstone. Grafts placed in the usual way. In this instance there was latent infection in the tissues and the wound became septic so that on December 10th the cartilage was removed. Was discharged January 7th, at which time the cough impulse was distinctly less than originally.

CASE XIII.—C. K., aged twenty-two years, admitted November 5, 1918; still in hospital. Wounded on April 16, 1918. Was not rendered unconscious but very dull that night.

Status Præsens.—There is a defect in the right frontal bone $2\frac{1}{2}$ inches in circumference, which pulsates freely and is tender to pressure.

Complaint.—Headache, inability to stand noise.

Operation (November 13, 1918).—Captain Shenstone. The only difficulty encountered was at the narrow inferior angle of the hiatus, where the separation of the dura was difficult. Although the dura was not opened in this instance, some fluid which closely resembled cerebrospinal fluid came away for some time, but that has now ceased.

At present the headaches are probably worse than before.

ON SOME LESIONS OBSERVED IN OPERATIONS FOR OLD INJURIES TO THE SPINAL CORD, WITH REMARKS AS TO TREATMENT *

BY CHARLES A. ELSBERG, M.D.
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MOST of those who have sustained an injury to the vertebral column and spinal cord—whether a fracture of the spine or a bullet or high explosive wound—have an irremediable cord lesion to which they will succumb sooner or later. In a small number the injury to the spinal cord and its nerve roots is not severe so that improvement with or without surgical interference is possible. A certain number of patients are seen by the surgeon many weeks or months after the trauma; some of these will require operative interference.

Among more than 200 spinal operations performed on my services at the New York Neurological Institute and at Mount Sinai Hospital, a number of old traumatic lesions have been met with. They may be divided into (1) those involving the membranes and (2) those of the cord and roots, including the roots of the cauda equina; combinations of these types are usually observed in a single patient.

1. *Lesions of the Spinal Membranes.*—Changes in the dura are a very frequent result of trauma to the spine. In the mildest cases, the dura is not thickened, its external surface is normal in appearance, but its internal surface is congested and has, over the affected area, lost its glistening appearance. With these changes, a cloudiness and thickening of the arachnoid is often associated (Fig. 5). The dura may be so much changed and so greatly thickened that it exerts a pressure upon the cord very like that of an extramedullary tumor. This condition was met with in a patient (Fig. 1) in whom the beginning of the symptoms dated back to a trauma one year before. In this case, the excision of the thickened area of dura was followed by gradual improvement of the symptoms.

The dura may be dark brown in color and the extradural fat so much altered in appearance that it could very well be mistaken for an extradural neoplasm. When such a thickened dura is excised, great care is necessary in order that the cord beneath shall not be injured. If the cord is found to be adherent to the dura and the arachnoid sac obliterated, the dura must be freed with care. If the arachnoid sac is found to be shut off above and below the lesion, the arachnoid must be incised above and below, in order that the pent-up cerebrospinal fluid can again circulate.

Calcareous deposits are often found on the inner surface of the dura and they may cause root pains or marked cord symptoms (Fig. 2). These calcareous deposits—which must not be confused with the calcareous

* Read at the meeting of the New York Neurological Society, February 4, 1919.

plaques which are so frequent in the arachnoid and which have no known pathological significance—are very apt to be associated with a localized arachnitis and are often found very firmly adherent to the pia on the cord. Great care must be taken in their removal, for they are often so firmly attached to the surface of the cord that injury to the cord structure might easily occur.

Adhesions between the pia of the cord and the dura with obliteration of the arachnoid are often met with and form part of the scars that are so often seen on the cord after a trauma. In some instances the cord is compressed by a mass of scar tissue which stretches across from the inner surface of the dura on one side to that on the other, and causes symptoms very like those of an extramedullary neoplasm. Part of the cicatricial tissue may be so firmly adherent to the cord that its excision is impossible. In such a patient, carefully made parallel incisions may be made through the scar tissue in a similar way to the decompressive incisions that are often made through the scar tissue by which a peripheral nerve is enveloped. Cicatrices in the dura, especially around the roots of the cauda equina, may cause severe root pains. Fig. 3 represents the condition found in a patient who had sustained a fracture of the first lumbar vertebra several years before and who was operated upon in the Neurological Institute. His symptoms were entirely relieved by the excision of the scar tissue. If one or two sensory roots are found to have been much damaged—especially if the patient had root pains corresponding to the injured roots—it is advisable to divide or excise the affected roots.

The changes that may be observed in the arachnoid after a vertebral trauma vary within wide limits. As is well known, this membrane is normally very thin, perfectly transparent and is distended with clear fluid (Fig. 4). Sometimes the arachnoid is found to be slightly thickened and cloudy (Fig. 5) over the entire area exposed. At other times a localized area on one or the other side of the cord is thickened, cloudy and adherent to the inner surface of the dura, as was observed in one of my patients. More often, however, the arachnoid is not only thickened and adherent to the dura, but also has formed adhesions to the spinal cord, so that irregular cavities filled with fluid may result (Fig. 6). These cases—whether occurring from inflammatory disease or trauma—have been called “adhesive arachnitis,” although this arachnitis must be considered a sign rather than a separate disease. New blood-vessels are apt to be formed if these arachnoid changes have occurred in the neighborhood of the posterior nerve roots (Fig. 7). If the vertebral trauma has been severe enough to cause a grave cord lesion, the arachnoid may have been destroyed and the arachnoid sac obliterated over a more or less localized area. In these patients we have found the subarachnoid space shut off above and below the affected area and filled by pent-up cerebrospinal fluid.

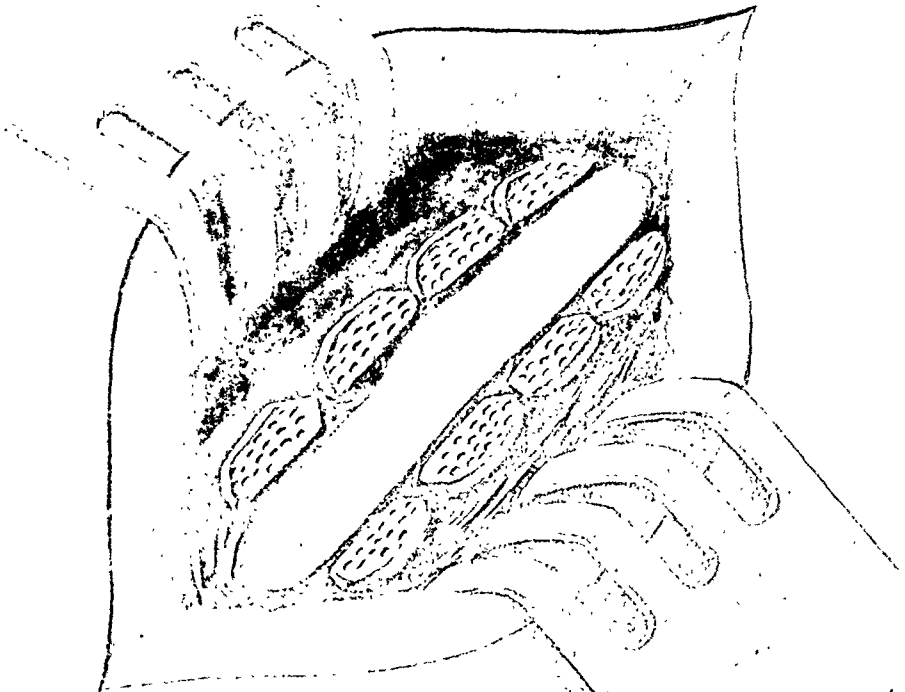


FIG. 1.—J. W. Pachymeningitis after trauma. Localized area of thickening of dura causing compression of cord. Appearance like that of an intradural tumor. Complete relief after excision of thickened dura.

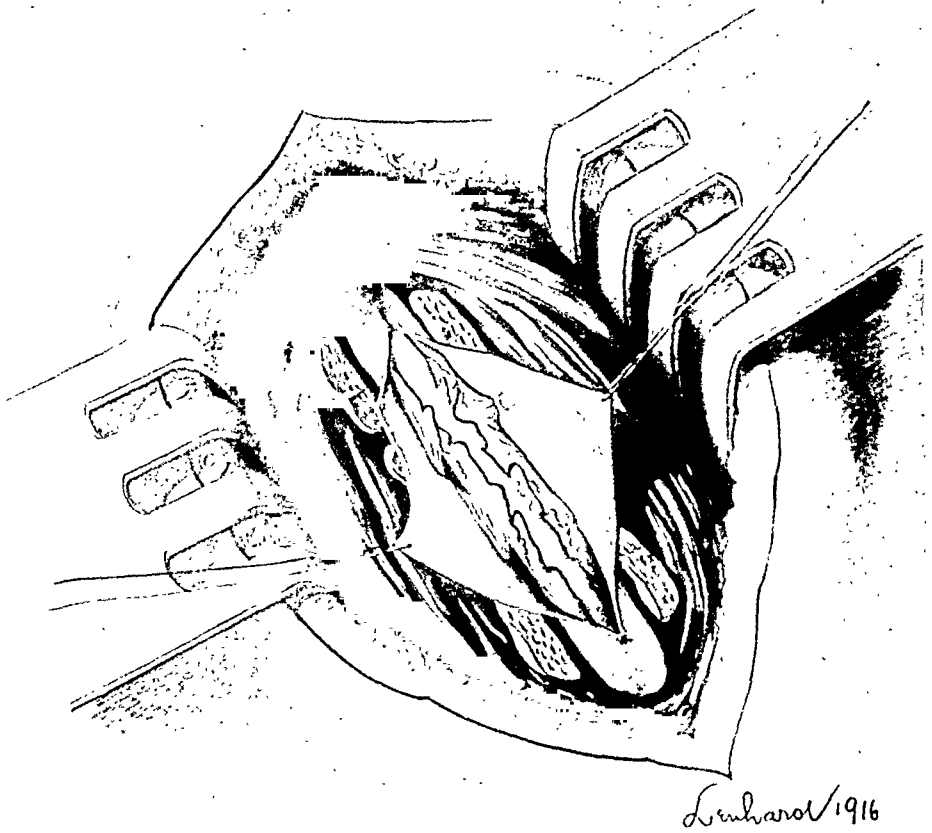


FIG. 2.—J. B. Calcareous deposit on inner surface of dura causing root and cord symptoms.

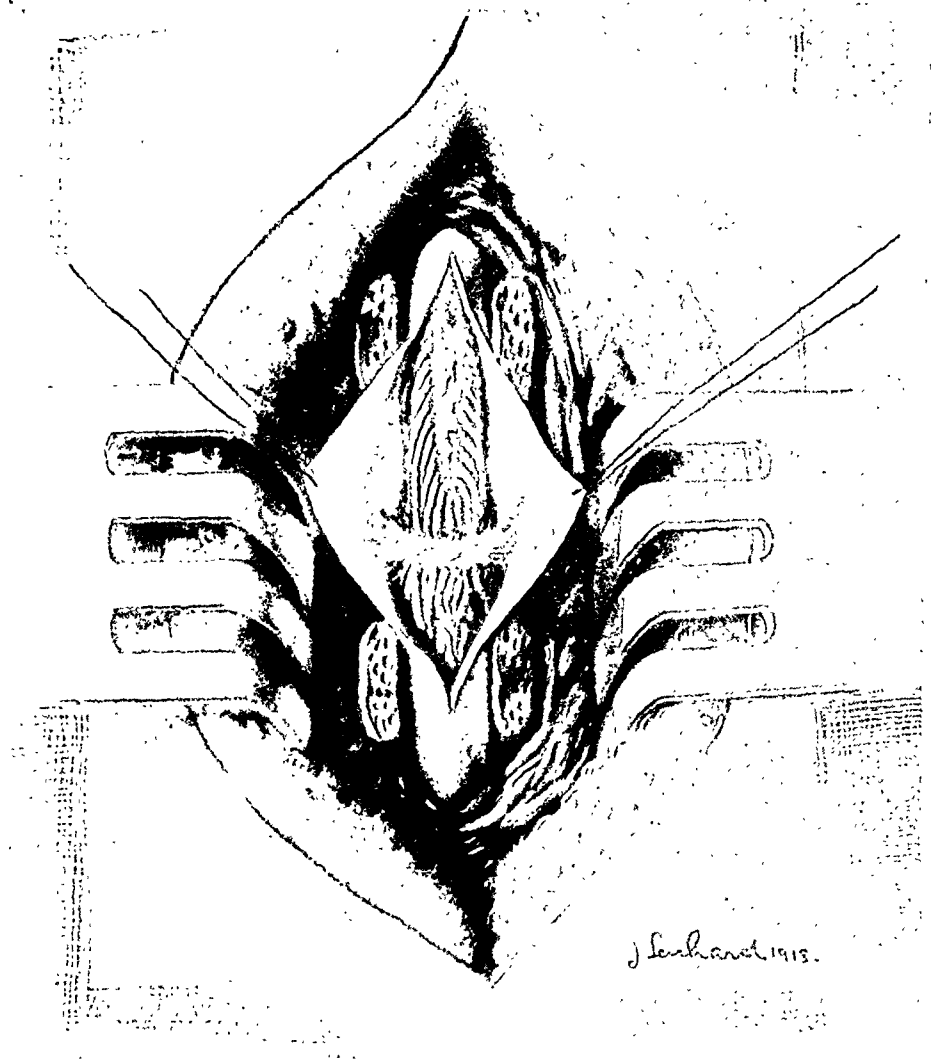


FIG. 3.—A.G. Compression of roots of cauda equina by cicatrix after old fracture of spine. Severe root pains. Excision of scar tissue. Complete relief.

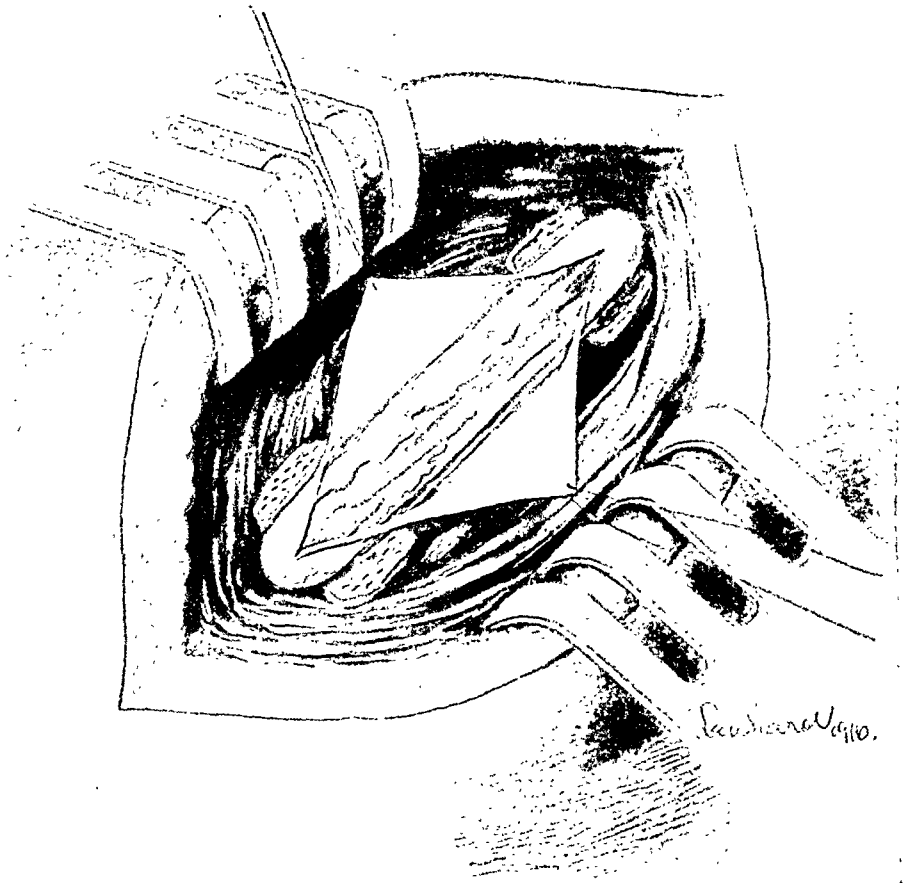


FIG. 4.—Appearance of cord inside of normal unopened arachnoid.



J. Leach 1914.

FIG. 5.—Cloudy arachnoid after old trauma of cord.

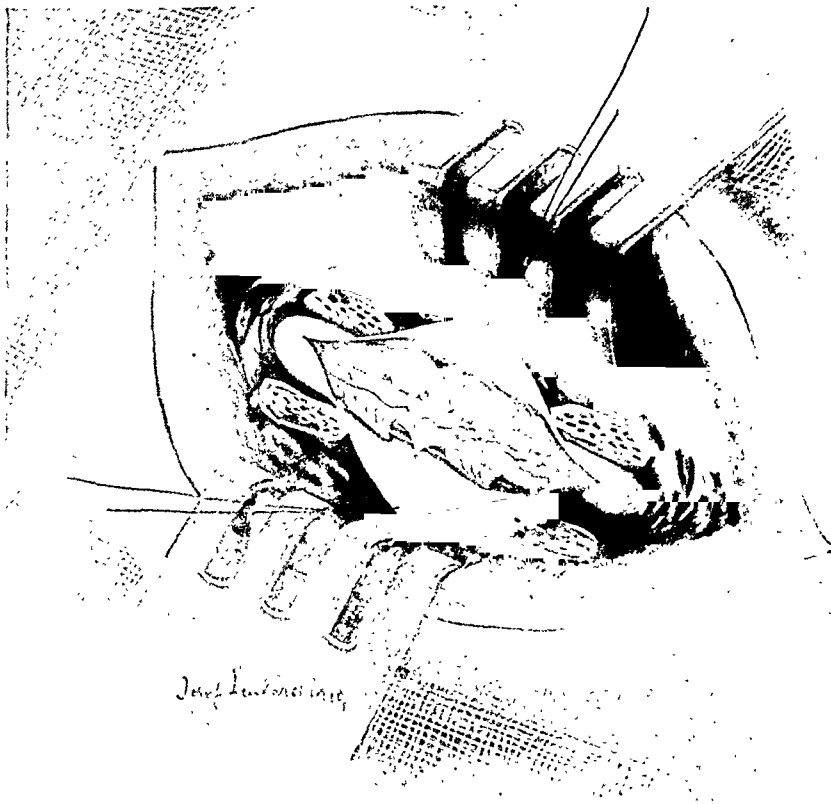


FIG. 6.—J. K. Laminectomy for old fracture of spine. Localized arachnitis with adhesions forming a mass of closed cavities filled with fluid.

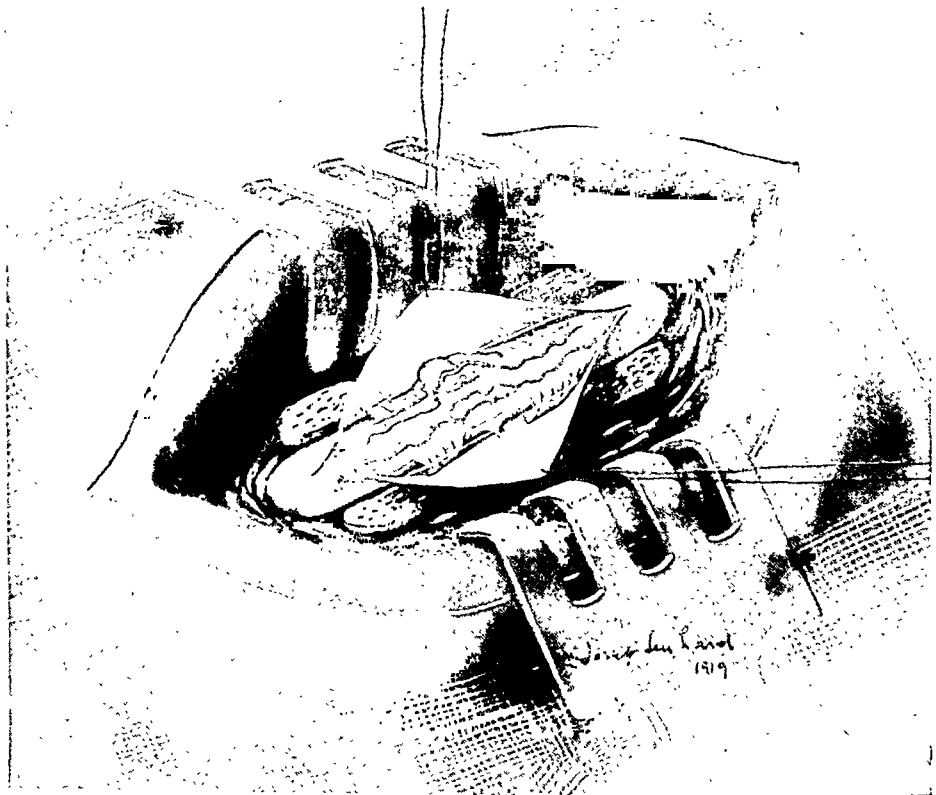


FIG. 7.—T. M. Laminectomy for old fracture of spine. Localized arachnitis with formation of new blood-vessels.

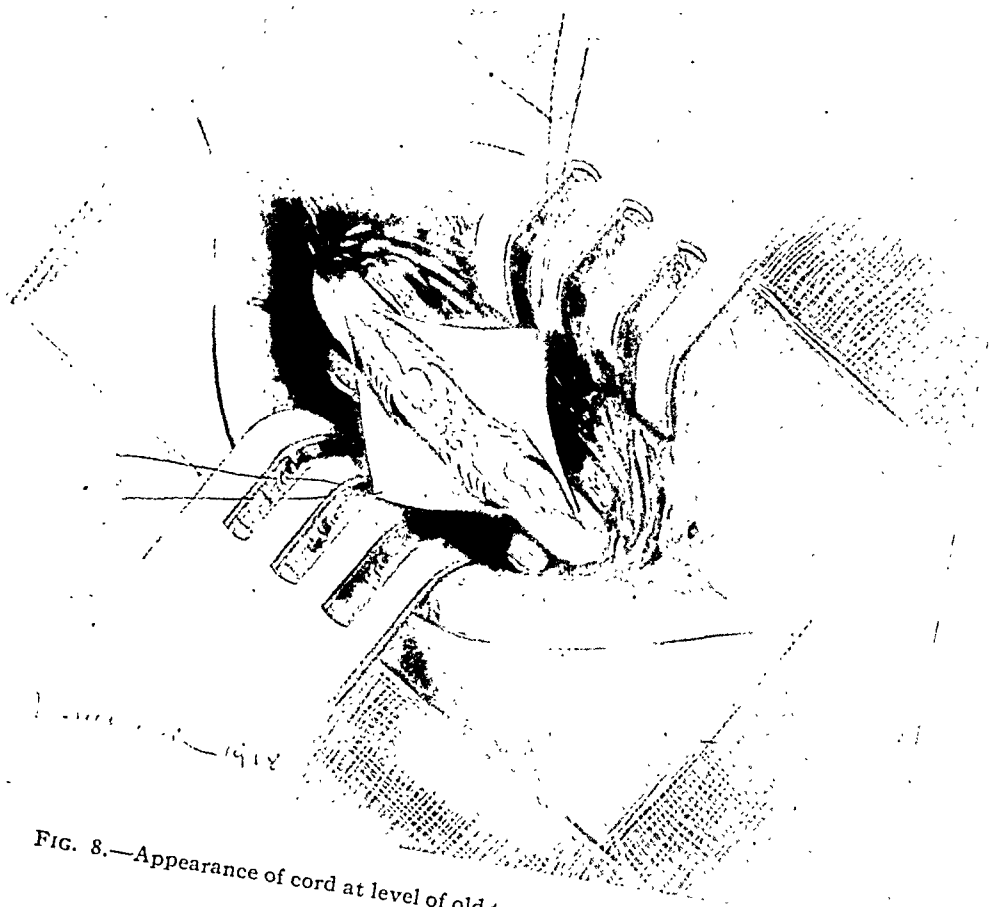


FIG. 8.—Appearance of cord at level of old transverse cord lesion.

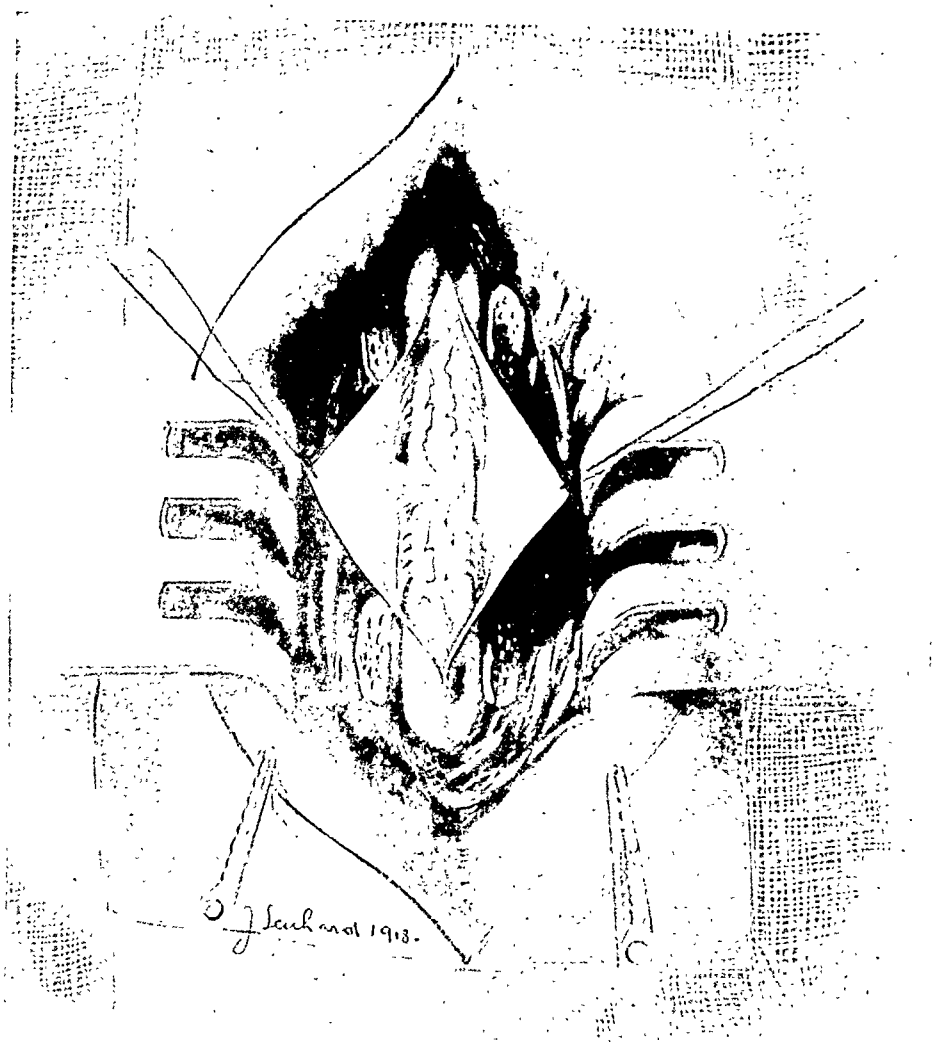


FIG. 9.—Laminectomy for old fracture of spine. Large mass of scar tissue extending from surface of cord to inner surface of dura.

2. *Changes in the Spinal Cord.*—The appearance of the spinal cord months or years after a trauma varies, of course, within wide limits. Surprisingly little macroscopic change may go hand in hand with very severe symptoms and very marked loss of function. Thus a slight increase in the vascularity over a localized area may be the only change in the gross appearance of the cord at the level of the old complete transverse lesion (Fig. 8). The spinal cord may appear normal to the eye in spite of a cavity in the cord filled with fluid (hydromyelia) or a hæmatomyelia. In these conditions, however, the cord often appears larger than normal and its consistency less firm so that the operator can recognize that the cord contains an abnormal amount of fluid. As is well known, cavities in the cord often extend over a large part of the cord, but I have seen the largest cavities in the lower dorsal, lumbar and sacral regions. In some of these patients, drainage of the fluid into the subdural space (subarachnoid) by a carefully made incision into the cord, may result in great benefit to the patient. If the cord tissue has been much thinned by the pressure, the condition is irremediable, as hopeless, in fact, as an advanced hydrocephalus.

When a thick scar is observed on the surface of the cord, it is never possible to say whether we are dealing alone with a surface lesion or whether a large part of the cord itself is involved, but I have seen superficial masses of scar tissue which could be excised without difficulty and without injury to the cord underneath (Figs. 9 and 10). On the other hand, the cicatrix may involve so much of the cord that the excision of the scar tissue would be certain to do more harm than good (Fig. 11). In these patients, the decompressive incisions through the superficial scar tissues above mentioned may relieve some of the pressure upon the cord at the affected level.

Very marked cord symptoms may be caused by distortion or narrowing of the spinal canal by new formed or dislocated bone, either through actual pressure upon the cord or through distortion of the canal and "angulation" of the cord. If the body of one vertebra has been dislocated backwards or if the body of one vertebra has been crushed and as a result the vertebræ above and below have become tilted, the cord may be stretched over a projecting mass of bone and subjected to both pressure and stretching. Very marked cord symptoms may result. We have seen very great improvement follow the removal of the projecting part of the body of a vertebra. A wide decompressive laminectomy allows the cord to bulge backwards and thus overcomes the marked angulation above described. We have seen numerous instances of this type and have seen great improvement follow the operation. Especially excellent results have followed the surgical interference when the lumbo-sacral cord and upper part of the cauda equina were angulated or compressed.

It is obviously unnecessary to advise that a cord compressed by dislocated or new formed bone which has markedly narrowed the spinal

canal, should be freed from the pressure by the removal of as much bone as is necessary.

Up to the present time there is no well supported evidence that the tissues of the cord can regenerate, and it is more than probable that functional regeneration is impossible. Therefore, operations for complete division of the spinal cord should never be attempted.

Lesions of the roots of the cauda equina are often seen as the results of bullet wounds and of fractures of the spine. Some of the roots may be divided and enveloped in scar tissue or the entire cauda equina is surrounded by a mass of scar. In some of these patients the scar tissue can be peeled off of the nerve roots, in others, the connective tissue is so dense and so many of the roots are involved, that the attempt to free the roots would be certain to cause a great deal of injury to roots that are still functionally useful. The surgeon must be very careful, therefore, in an operation of this kind, not to attempt to do too much. Sometimes one can make only decompressive incisions in a longitudinal direction through the scar tissue between the nerve roots. If we were more certain that regeneration of a divided anterior root is always satisfactory, the resection of anterior nerve roots with subsequent nerve suture would be justifiable. Much experimental work is still necessary, however, to place such a procedure on a firm foundation. The procedure may especially be called for in injuries of the nerves of the cauda equina. Everyone seems to be agreed that the ends of a divided caudal nerve root should be sutured together, but the results thus far obtained have been unsatisfactory. I have never seen a satisfactory result from such a suture.

Finally, the subject of the lesions that are met with in old injuries of the cord, should not be dismissed without a short consideration of the question of the indications for treatment.

As opinions are still at great variance, the question, "What symptoms and signs justify operative interference?" is an all-important one.

The neurologist and the surgeon must always keep clearly before them what they can hope to accomplish by an operation for old injury to the spinal cord—whether adhesions which compress the cord or nerve roots are to be divided, an angulation of the cord straightened out, the spinal canal narrowed or deformed by dislocated or new formed bone to be enlarged, thickened dura to be excised, etc. In order to arrive at a proper conclusion, thorough and repeated neurological examinations and good X-ray plates are necessary.

1. Without doubt, surgical relief is impossible if the symptoms of a complete transverse lesion have existed from the time of the trauma even if, after months, reflexes have returned and spasticity is marked.

2. There is no hope of relieving a patient with the symptoms and signs of an incomplete cord lesion who has large bed sores and who is much emaciated. In these individuals, the cord lesion is surely an irremediable one and is often complicated by pyelitis or pyelonephritis.



FIG. 10.—Laminectomy for old fracture of lumbar vertebræ. A mass of scar tissue is compressing a number of the roots of the cauda equina.



FIG. 11.—An irremediable cord lesion after old injury to the spine. The spinal cord is much thinned at the level of the lesion and is adherent to the inner surface of the dura.

I have never seen any useful improvement occur after operative interference, although I often tried to benefit the patient by surgery.

3. Individuals who have, after a spinal trauma, improved considerably for a period of months but in whom the improvement has stopped before useful function of the limbs has been regained, should be operated upon either if a marked angulation of the cord has remained or the X-ray shows a narrowing of the spinal canal by dislocated or new-formed bone, unless the examination shows that there is a dissociated disturbance of superficial sensation. This dissociation is, of course, an evidence that there is an old hæmatomyelia or perhaps a gliosis secondary to an old intramedullary hemorrhage.

4. If there has been considerable return of power in the lower limbs and the condition has become stationary, and if locomotion is interfered with by the spasticity, a laminectomy and division of the appropriate posterior nerve roots—according to the principles laid down by Foerster—is often followed by very satisfactory results.

In my experience, posterior root section for the spasticity of Little's disease has given few good results, no matter how thorough the after treatment. I have, however, seen some very excellent results of rhizotomy in old spasticities which have followed a spinal traumatic lesion and in some of the cases of residual spasticity after the removal of a long existing extramedullary tumor of the spinal cord.

5. Severe root pains at or near the upper level of the lesion, if they can not be relieved by immobilization of the spine by a plaster jacket or other apparatus, may demand operative interference, and the surgical procedure in these patients must consist of a wide decompressive laminectomy with division of the necessary posterior nerve roots. One of the most successful results of operative interference for old spinal fracture that I have ever observed was in a bedridden patient in whom severe motor and sensory disturbances in the lower limbs which remained after a fracture of the spine sustained many years before, were complicated by recurring attacks of root pains referred to the lower dorsal roots. In this patient, a wide decompressive laminectomy with division of the affected nerve roots was followed not only by relief of the pain but by a great improvement in the motor and sensory symptoms, so that the patient was again able to walk about.

6. Can we benefit a patient who has vesical incontinence left after an old spinal injury of the lumbo-sacral cord or cauda equina? This question is a most important one. The individual may have regained complete or almost complete control of his limbs, but his life is made a miserable one by the urinary incontinence. I have recently seen several soldiers who had recovered very satisfactorily from all of their symptoms excepting the bladder paralysis, and it would have been a most happy result if by an intradural root anastomosis, a return of bladder control could have been obtained. Theoretically, regeneration of the anterior nerve roots

should be possible and technically the anastomosis of anterior roots above the lesion and the third and fourth sacral roots (which partly control the bladder musculature *) is not so very difficult. The experiments of Cadwallader and Sweet, of Frazier and Allen, and more especially those of Kilvington, show that such an anastomosis can be successful; up to the present time experiences in man have been inconclusive but the subject is one pregnant with possibilities for the future.

Among the last 200 laminectomies I have performed, 20 operations were done for spinal lesions due to old fractures or wounds of the vertebral column. Of these patients, 8 were completely relieved of their symptoms and 6 were greatly improved. In 6 there was little or no improvement. With increasing experience, still better results should be obtained in the future.

* The bladder receives its nerve supply partly from the somatic and partly from the autonomic systems.

ON THE DIAGNOSIS AND THERAPY OF BONE TYPHOID *

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It has been pointed out by various authors who have occupied themselves with the study of typhoid complications in the bone system that the therapy in such cases is far from satisfactory as regards the results.¹ Although no small number of cases of different forms of typhoid bone processes have been published, and the clinical course of this disease studied in considerable detail, yet our knowledge is defective in this respect also. With the increasing use of radiography in diseases of the bone system, such diseases will, no doubt, be more frequently discovered and localized than has hitherto been the case, but from a radiogram one cannot draw any conclusions respecting the determining etiological factor, at least, no conclusions can be arrived at in a large percentage of bone diseases of the focus type.

Typhoid has been very closely studied from the bacteriological and pathologic-anatomical point of view, and the Eberth bacilli are among those bacteria which we have least difficulty in definitely examining. Owing to this circumstance, and to the fact that the risk of a wrong conclusion with reference especially to the paragglutinability of other specific sera is comparatively slight as regards typhoid, I have by means of bacteriological examinations of bacteria obtained from isolated foci succeeded in proving the typhoid nature of the disease when no clinical support for such a diagnosis existed. As localization is interesting and illustrative of the hæmatogen-metastatic propagation, and as, besides, the therapeutic means employed may possibly be of some value, I will here describe the case.

CASE I.—The patient, a female, aged eighteen years, was admitted to Serafimer Hospital, November 22, 1917. Her parents and ten brothers and sisters were alive and healthy. She had had measles as a child, *but otherwise has never been ill*. There has been no epidemic of typhoid in her native place. Three years ago she got pains in her right hip-joint, diagnosed by the doctor as rheumatic; she kept to her bed for two months, does not know if she had fever during that time, but had no symptoms from any other organ, and did not feel ill otherwise. Since that time no further trouble from her hip. Some months later, without any external cause, a sore showed itself immediately below the left collar-bone, and spread gradually till it obtained about the size of a child's hand. There was no tenderness and no pain, very inconsiderable secretion from the sore, which, under treatment with

* Read before the Swedish Medical Association, March, 1918.

¹ Murphy, John B., Surgery, Gynecology and Obstetrics, August, 1916.

ointment, healed in about a year's time, leaving a ridgy cicatrix. In December, 1916, consequently six months later, she again got pains in the right hip, and was then admitted to the hospital in her native place. The following is an extract from the journal kept there: "Has latterly had difficulty in supporting herself on the right leg. Large fluctuating area over the right gluteal region. Mobility in hip-joint somewhat restricted, no pain worth mentioning in movement. Radiogram shows a destructive process in the margin of the acetabulum, the caput contour indistinct. Puncture of abscess and injection of iodoform glycerine. Horizontal position. Discharged February, 1917. Diagnosis, coxitis "tbc. dx."

Limped slightly after discharge from hospital. In the beginning of November, 1917, she noticed directly above the right trochanter a red spot, which, after a week's time, began to ulcerate. No pains and but slight secretion. The ulceration spread gradually. At about the same time was observed a redness and induration on the extensor side of the left arm. Admitted to Serafimer Hospital November 22, 1917.

Status præsens on admission: A thin girl, seemingly of weak intellect. Temperature non-febrile, pulse 80, nothing to notice. Nothing abnormal as regards lungs, heart or urine, neither liver nor spleen enlarged. Weight, kilo 41.7.

Local symptoms: Immediately below the medial portion of the left collar-bone a deep-ridged scar, about the size of a florin, with sharply defined rounded edges. In the bone underneath close to the sternum is to be felt a half-moon-shaped defect in the bone of the size of a bean. No tenderness or swelling.

The sternal end of the right collar-bone feels somewhat thickened, but there is absolutely no tenderness.

In the middle of the dorsal side of the over arm can be felt a longitudinal infiltration in the subcutaneous tissues, about 8 cm. long and 3 cm. wide. This, together with the skin, can be pushed against the underlying muscles, and is of fairly firm consistency, but with smaller, softer portions (about as large as the finger-tip) which seem to be defects. The skin in this area is slightly reddish, with a lighter central zone. The whole is perfectly free from any tenderness. Puncture yielded negative result.

Just above the right trochanter major is a surface ulceration, almost circular in form, of the size of a farthing; the edges of the sore are sharp, firm, not protuberant nor undermined. The skin around is reddened, and the bottom of the sore covered with necrotic products. Induration, but no tenderness round the sore. With a probe one comes 7 cm. in towards the hip-joint without anywhere coming upon exposed bone.

Mobility of the hip-joint somewhat restricted in all movements, except the rotatory. No painful limp in walking. No pain in attempted movements of the hip-joint, or in shock palpation longitudinally in the leg. No shortening.

Radiogram same day shows: "Shanton's line unbroken. Articular cartilage of normal height. Lime percentage in caput and collum

femoris less, generally speaking, on the right side than on the left. In the upper part of the collum and in the caput are to be seen scattered rarefied spots. No defined contour alteration in the caput, but the contour lines are not so sharp as on the left side. The radiogram most nearly resembles a conical arthritis without probable alteration in the bone (Forsell).

"The sternal third of the left clavicle is distinctly narrower than the right; the contours are seen; the bone picture does not stand out clearly here; it appears to be thinner than in the other parts. No focus form enlargement; the sternal end seems to be unaltered. The sternal end of the right clavicle shows a rather closely-marked rarefied area of the size of a hazelnut. No periosteal deposits; surrounding bone unaltered (Hansson)."

Wassermann's reaction in the blood negative. The blood serum does not agglutinate typhoid or paratyphoid bacilli.

Blood analysis *H.b.* (Sahli) = 70 per cent.; red blood-corpuscles, 400,000 per millimetre; white blood-corpuscles, 14,000 per millimetre. Differential calculus of 400 cells with Giemsa coloring gave: Neutrophiles, 52 per cent.; eosinophiles, 6 per cent.; basophiles, 1 per cent.; transition forms, 2 per cent.; small lymphocytes, 34 per cent., and large lymphocytes, 5 per cent., equal 39 per cent. lymphocytes. Subcutaneous tuberculine injections in increasing doses with 1, 2, 5 m.g. produced no reaction, either general or local.

As the etiological diagnosis for this multiple bone disintegration and skin infiltration seemed to be absolutely obscure, and as it was evident that no conclusions could be arrived at by means of a culture from the wound in the hip which had been open for a fortnight, a chiselling-up of the right collar-bone was performed on December 7th, and a peculiarly disintegrated bone focus was scraped out; the hole was filled chiefly with granulation tissue, no sequestra. A pathologic-anatomical examination showed only a fibrous transformation of the marrow of the bone in certain parts (Hellman).

The bacteriological examination conducted by Dr. J. Tillgren showed here and there in a direct preparation colored with methylen blue colonies in a granulation tissue poor in cells. In culture on agar a pure culture of the same kind of colonies was obtained; this proved to be gram-negative. The bacilli show no color change from lakmus molke, and no grape-sugar fermentation. In propagation on endo-plates there were colorless colonies.

Agglutination experiments. With serum from typhoid and paratyphoid patients, agglutination in solution 1 to 100, strongest agglutination with typhoid blood.

Repeated examinations of the blood have given negative Widal. The presence of typhoid bacilli in the urine or fæces could not be proved in spite of diligent search. Test excision from the infiltration on the upper arm showed only fibrously altered fatty tissue.

December 18th, condition unchanged. Operation wound healing *per primam*. Infiltration on the upper arm same as on admission. Radiography of both upper arms.

"In the right shoulder joint is to be seen within the humeri-epiphyseal area, and in the adjacent part of the diaphysis an elevation of the bone due to a periostic deposit. In the epiphyseal area a couple of focus-form bone disintegrations. In left caput humeri a rarefaction of the bone structure in the entire caput, with limit towards diaphysis rather sharply defined. In lateral portion of epiphyseal area appears a clearly marked rarefaction of the bone, possibly a bone abscess (Foessel and Ström)."

Carrel drainage with Dakin's solution was applied to the fistula on the hip-joint for six days.

From the cultures obtained from the operation Doctor Tillgren prepared a vaccine by killing the bacteria with $+58^{\circ}$ C. for half an hour and sitting up in $\frac{1}{2}$ per cent. carbolic acid. Vaccine treatment was begun December 18th with subcutaneous injections and a beginning dose of 25,000,000 gradually increased to a dose of 5 milliards (5 c.c.). No reaction on the patient's part, and no discomfort after the injections.

January 14, 1918. General condition considerably improved. Weight increased by 4.2 kilos.

Wound and fistula in the trochanter region healed. Patient now walks without limping. Mobility in hip-joint unrestricted. Infiltration on upper arm has disappeared.

January 26, 1918. Radiogram shows bone alterations as before, except in the scraped out clavicle focus, which has now the appearance of a well-defined bone defect of the size of a pea. Culture of typhoid bacillus in the blood yielded a negative result.

February 16, 1918. The patient's serum agglutinizes her own bacteria as well as other typhoid bacilli in dilution (one to two hundred). As the virulence of the bacilli seemed remarkably low in experiments on guinea-pigs (the animals surviving after an intraperitoneal injection of 1 c.cm. bacterial vaccine, which was calculated to be three times the lethal strength for ordinary typhoid bacilli), it was decided to seek to raise the virulence of the bacteria through the passages of the animals, and thereafter to prepare a new vaccine. This was done, and after passage through five guinea-pigs, a culture was obtained with lethal effect upon guinea-pigs after twenty-four hours, given in above-mentioned dose. A vaccine was now prepared from this stock, and after a cautious experiment with a small subcutaneous dose of the new vaccine, this was administered in increasing quantities every second day up to 5,000,000,000, which dose was repeated four times in succession.

The patient was discharged May 19, 1918, completely free of symptoms, with positive Widal. An examination in November, 1918, shows nothing noteworthy in her condition.

COMMENT

We have here an exquisite chronically continued pyæmic infection with foci in the bone, joints and subcutaneous tissues. Clinically, all data for etiology are lacking, the patient has never had an illness before, and especially has never suffered from any serious febrile illness. To the theory of tuberculosis

BONE TYPHOID

were opposed the following circumstances: Localization, absence of tubercular alterations of other organs, the completely non-febrile course of the illness, (the tendency of the coxitis) to relapse without restriction of the mobility of the joints; partly also the negative result of tubercular experiments, and, finally, the X-ray showings, in which, in spite of the protracted duration of the illness, no calcification, or only very slight, could be discovered. The appearance of the cicatrix under the left clavicle, and the sore at the trochanter suggested a luxation. A hereditary luxation was improbable, as the parents are both healthy, and have ten other healthy children; an acquired one was also unlikely in a sixteen-year-old virgo with negative Wassermann. The radiograms did not favor such a diagnosis either (absence of periostitis or bone sclerosis). The normal blood scheme was against leucæmia, myelomitis or other diseases of the system. The most likely assumption was that of a chronic septic staphylococcic-osteomyelitis with unusually weakened virus, but even on this assumption it was remarkable that the temperature was absolutely normal, and that there was complete absence of tenderness and of reactive processes in the bone from the periosteum, and in the immediate environment of the foci.

The course of the disease, as well as all the clinical characteristics, were most in accordance with a diagnosis of typhoid in the bone system, so we at once took Widal, and sought in the anamnesis after some previous illness which could be explained as typhoid. As both these hypotheses gave negative results, the only possibility left was to seek to throw light on the etiology by means of a bacteriological investigation from another closed focus.

This investigation has shown that we probably have to do with a bacillus of the typhus-coli group. The circumstances against the coli assumption are the manner of growth on endo-plates with glucose-agar and lakmus molke, and, with a certain reservation, the agglutinability for typhoid serum.

Putting together the clinical course, the bacteriological result, the pathologic-anatomical alterations, and the X-ray showings, it may be regarded as proved that we have here a case of typhus or possibly paratyphus chronic pyæmia. The fact that the patient had no knowledge of any preceding typhoid need not constitute any objection, for, as is well known, this disease, especially in childhood, can often have a quite untypical course, while cases of so-called bacillus carriers who have never, in the clinical sense, been ill of typhoid, are already well known. That this patient should be dangerous as a bacillus carrier in the ordinary sense may be regarded as quite out of the question, for, in spite of repeated examinations during a protracted period, no typhoid bacilli could be found in fæces or urine.

There are also instances of exactly reversed conditions. Thus Kasper¹ in 1913 reported a case of typhoid periostitis in the tibia; in this case the typhoid had occurred eight years earlier, and the pus contained Eberth's bacilli in pure culture. Widal was positive in this case, and typhoid bacilli were

¹ Kasper, Fritz., *Mitteilungen aus der Grenzgebiet*, 1913, h. 5.

found both in the blood and the faeces. This case is explained as being an auto-reinfection in a bacillus carrier, without any abdominal disease symptoms.

Osteitis of the above type with multiple foci has been already described many times. It appears from literature, however, that only 4 per cent. of the typhus-osteitis have occurred in the multiple manner. As shown in the above case, the greater number of the foci exhibited no symptoms whatever, but were discovered almost by chance, in the course of a systematic Röntgen skeleton examination. As such an examination had never been conducted before in similar cases, it may very well be possible that the foci described as isolated have had other foci, and that thus the multiple localization is considerably more common than is generally supposed. This appears probable also from the point of view that the foci are to be regarded as the result of pyæmic metastization. The significance of the multiplicity in localization lies in the fact that it appears to call for a different therapy from that employed for isolated foci, which are easily accessible to direct surgical treatment—consisting of chiselling up and scraping out; and, further, because it seems well worth while in such cases of extended dissemination of infection to make an experiment with vaccine therapy, or, possibly sero-therapy in order to find out the value of these methods. It is well known that bacteria can remain long completely latent, and subsequently show symptoms. Thus Buschke relates a case in which he found a pure culture of typhus bacilli occur years after the patient had had typhoid. Fogh, twenty-three years after, and other investigators record cases of the persistence of typhus bacilli in bone six, seven, ten, thirteen, even fifteen years after the illness. The greater majority of typhoid bone complications show symptoms months or even years after the acute infection has ceased, although not so few cases have been known to occur also during the period of fever or convalescence.

It is evident from the literature on the subject that the type of the acute infection which the patient has passed through does not play any important part in the occurrence of subsequent bone complications. Murphy calculates that in 48 per cent. of the cases the primary infection is slight, or moderately severe, and in 42 per cent. severe. To this may be added those cases in which no intestinal or general symptoms have been observed, and those cases of chronic bacillus carriers in which the individual has never shown any symptom of typhus abdominalis; which shows that purely abortive cases can also produce hæmatogenous metastization.

As regards the frequency of bone complications in typhoid, Murphy has found 164 cases in 18,840 cases of typhoid collected from different authors—thus less than 1 per cent. Funcke found in 700 osteomyelitis cases only 3 with Eberth's bacillus as cause. It has, however, been pointed out that the typhus osteitis cases are probably considerably commoner, though they are often overlooked on account of the insignificance of the clinical symptoms, and also because many such cases in all probability heal spontaneously, or pass into a state of chronic latency. This view finds, above all, support in the observations of many years' latency mentioned above, and also in the case here described with objectively proved foci containing typhoid bacilli in

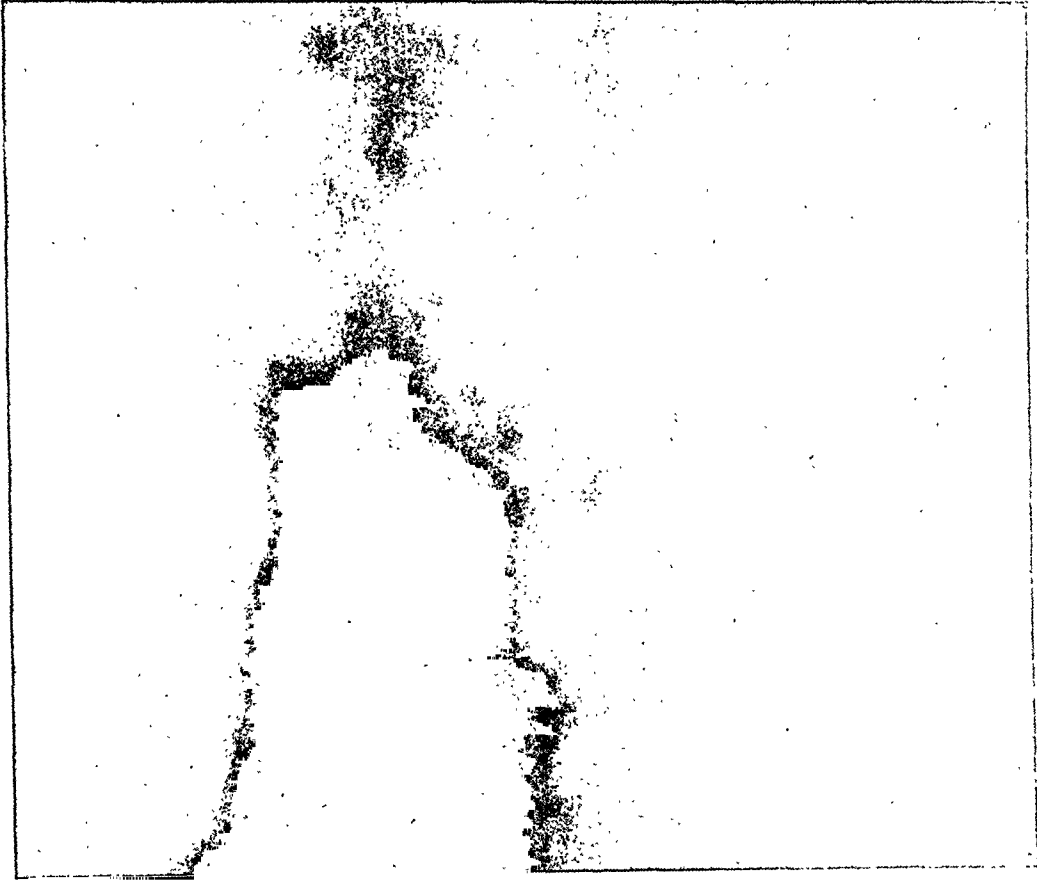


FIG. 1.—Radiogram showing the forms in right clavicle.



FIG. 2.—Left humerus before the vaccin-therapy.



FIG. 3.—Left humerus, the autovaccin-therapy ended.

FIG. 4.—Right humerus, before the therapy.

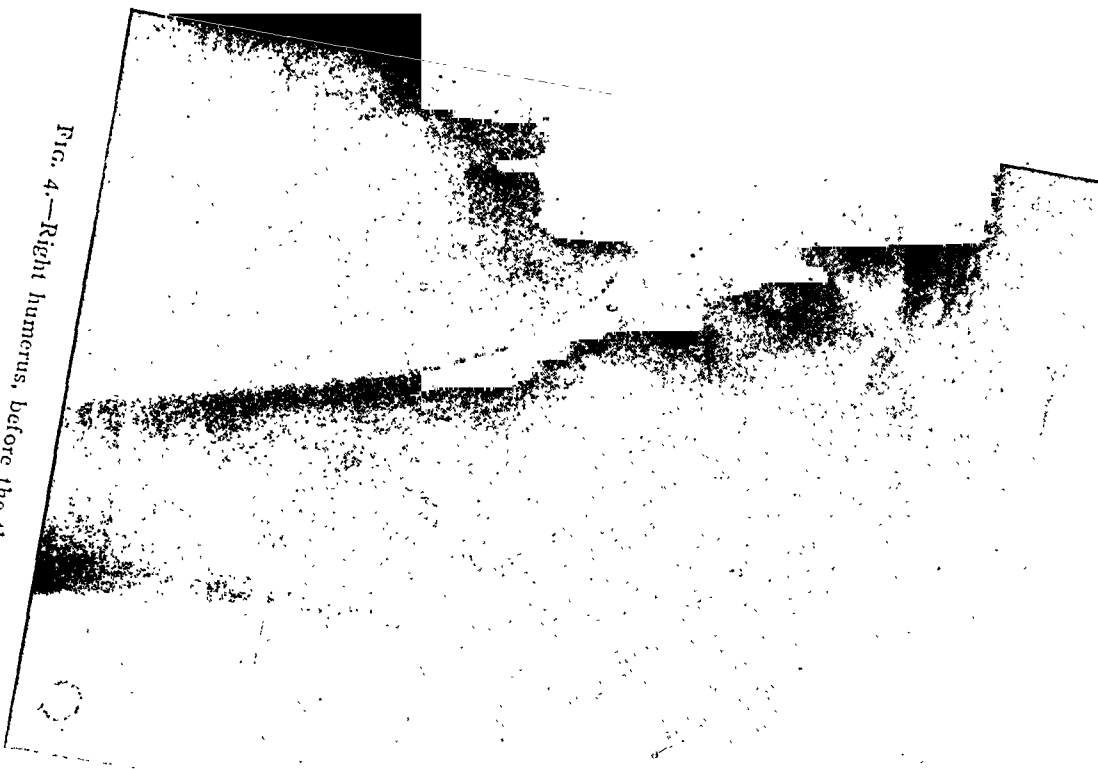
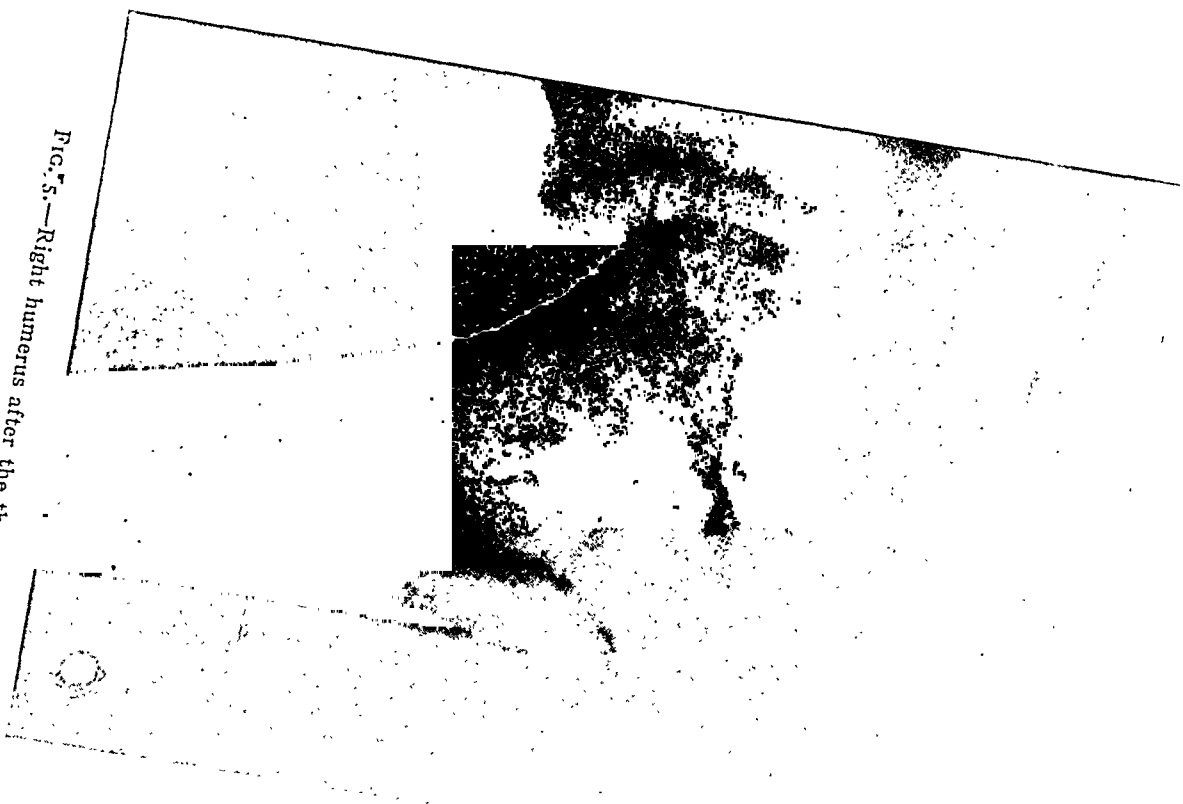


FIG. 5.—Right humerus after the therapy.



pure culture, but without any clinical symptom whatever. The lengthy course of the illness, with manifestations occurring here and there in the subcutaneous tissues, would also seem to indicate that the disease was not in complete latency, but possibly, in conjunction with traumata or infections may be regarded as receiving new propagation, and from an eventual primary focus spreading to the blood-vessels, especially when the negative result of Widal's reaction shows the absence of anticorpuscles, or, at least, of agglutins in the blood. The quality of this blood in the case in question seems to me to indicate the existence of one or several closed foci which have not stood in continuous connection with the blood.

A circumstance which also seems to indicate that it has rather been a question of chronic pyæmic typhoid than of auto-re-infection by typhoid bacillus carriers is that Widal's reaction, which on admission was negative, became positive under vaccine treatment. It would appear from this that virus which was of remarkably low virulence, as shown by experiments on animals, did not, however, exist in the body so extensively, or in such open connection with the blood that it could stimulate to the formation of antigen when the capacity of the body to do this was evidently quite unaltered.

The result of the treatment with autogene vaccine is of great interest. Similar experiments have been previously made with chronic bacillus carriers, but with negative result. The conditions are not, however, analogous, because in such cases there has been a bacteria culture in the gall itself, and the bacilli have not there come in direct contact with the anticorpuscles of the blood. From the purely theoretic point of view it was rather to be assumed that the bacteria in the bone foci which had arisen from hæmatogenous propagation could be more immediately influenced by a directly intended antigen formation.

It would be too daring to draw any definite conclusions from this single case, but I have wished the experiments to be more generally known, especially with reference to my previously expressed opinion that multiple typhus foci in the bone system are much commoner than has been hitherto believed, and that therapy, in such cases, must not be satisfied with a simple intervention in that focus which, for the time, shows symptoms, but ought, as far as possible, to strive to render harmless the bacteria wherever they can be localized. Nothing but continued experiment in this direction can decide the value of the method of treatment here proposed, but that this treatment has had a favorable effect upon the disease is indicated by the fact of the rapid healing of the fistula in the trochanter region, compared with the period of over a year which the fistula (also of spontaneous origin) under the clavicle required for healing; further, the return of mobility in the hip-joint, as well as the disappearance of lameness, the resorption of infiltration in the subcutis of the over arm, and finally, the very considerable improvement in the patient's general condition.

The objective proof that the vaccination took effect upon the organism is furnished by the fact that Widal's reaction became positive after the injections. The other bone alterations have shown no subsequent symptoms,

and Röntgen examination has not been able to prove the existence of any progressive destruction, nor the appearance of any new foci.

Vaccination is employed prophylactically to a considerable extent against typhus and with excellent results. Attempts have been made with curative aim to make use of partly convalescent serum, partly dead culture in cases of abdominal typhoid at its acute stage, but as is natural to expect, it is singularly difficult to judge of the results, although most authors believe themselves to have obtained favorable effects from this treatment. The figures vary in the different statistics—in some cases vaccine therapy is believed to have been directly instrumental in saving life, in others no effect whatever can be proved.

As regards the possibility of judging of the results of vaccine therapy, it may be stated with certainty that this is considerably more difficult during the acute stage than in post-typhoid complications. In the latter it can happen, as was the case here, that anticorpuscles no longer existed, or at least, their presence in the blood could not be proved with the usual reactions; artificial antigen formation can, therefore, theoretically, be considered to have greater likelihood to exert influence upon the disease.

Brekke has, in 1916, given an account of extensive experiments in the technic and application of different serological methods of showing the existence of typhoid anticorpuscles.

He examined sera from normal individuals, from typhoid patients, and from persons vaccinated for typhoid. He has found that the quantity of bactericidal amboceptera in a normal serum is very small, also that the agglutinating capacity of normal serum is very inconsiderable. In general, the presence of agglutination could not be proved in a dilution of 1 in 40, which the author considers to be the top limit for the agglutinative capacity of normal serum.

In typhoid patients, on the other hand, could be observed a considerable production of amboceptera; the maximum quantity of amboceptera existed at the close of the febrile stage. After this the quantity diminished. The curve of agglutination showed itself more irregular, although the agglutination production seemed to take place chiefly during the fever stage. There was no distinct correspondence between the course of the two curves; Brekke gives it as his opinion, however, that the production of the two substances does not appear to take place absolutely without connection. In a high proportion of amboceptera he found a constant higher agglutinability. The complementary curve appears to be independent of the course of the disease.

No distinct relation could be proved to exist between the clinical picture of the disease, its severer or milder course, etc., and the quantity of anticorpuscles. Even three years after the illness the percentage of amboceptera is higher than normal; the agglutinations diminish much more rapidly.

After vaccination for typhoid the formation of anticorpuscles increases also to the highest degree after two injections. The number of these specific anticorpuscles is, in vaccination, in some cases as great as in the disease itself, but, as a rule, it is somewhat less. During the whole of the first year after

vaccination the quantity of both amboceptera and agglutinins is higher than normal.

Brekke's experiments show, therefore, that the conditions in serum during the illness and during vaccination are absolutely parallel and qualitatively identical, even though differences possibly exist quantitatively.

It is of interest in this case that when the patient had not had any clinical typhoid, and on admission still gives negative Widal, even in low dilutions, in spite of multiple foci that the serological vaccination result is agglutination formation which can be proved by the patient's own bacteria in dilution, as these agglutinate by convalescent serum. Brekke has shown that amboceptera production as a rule accompanies agglutination production; it does not, therefore, seem to be a rash conclusion to draw from the result of the treatment in this case that anticorpuscles are developed during vaccination, and that one can therefore hope that the other foci can, by this means, be hindered in their further development. The fact that agglutinations are formed seems to me to favor the idea that the bacteria were originally of very low virulence, otherwise one ought to have expected a previous agglutination formation. That such an antigen formation can take place by reinfection is apparent from Kasper's case, the result of the treatment here tried seems also in favor of this, for it would be difficult to imagine a bacterial hæmatogenous propagation such as exists here, unless the formation of anticorpuscles at least during the transport should have been in some measure stimulated. That continuous propagation took place cannot be proved, but this seems probable from the relatively rapid occurrence of subcutaneous infiltration.

CONCLUSIONS

1. Multiple typhoid bone foci are probably commoner than is shown by statistics.
2. A condition of disease can occur even when no clinical typhoid record of disease can be found; the course of the primary disease is without significance for the appearance of bone metastasis.
3. It is not necessary that Widal's reaction should give positive result, even if multiple foci exist.
4. Systematic Röntgen examination is desirable for the entire skeleton in isolated bone foci, in order to determine the treatment.
5. The diagnosis can be made with certainty only by means of bacteriological examination of the foci discovered. Radiographs show nothing specific, only the existence and localization of foci.
6. The single foci are quickly and securely accessible for direct operative treatment.
7. Vaccination therapy has, theoretically, the possibility of hindering the further development of bacteria, at least in those cases where Widal's reaction is negative.
8. Autogenous therapy has been tried in one case without discomfort to the patient, and with apparently good results. There seems to be good reason for continued experiments in this direction.

DIAPHRAGMATIC HERNIA

ITS UNSUSPECTED FREQUENCY: ITS DIAGNOSIS: TECHNIC FOR RADICAL CURE

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It is the purpose of this paper to call the attention of internists and of surgeons to the frequency of diaphragmatic hernias, especially small ones, because patients suffering from this condition are not properly treated, for the reason that the correct diagnosis is not made, and therefore the treatment is based on curing pathological conditions which do not exist, or co-exist with the diaphragmatic hernia, and the result of the treatment must be, at least, absolutely negative. If diagnosis of diaphragmatic hernia, when a great portion of the stomach, or all the stomach and several loops of intestine have emigrated in the thoracic cavity is made positive, at the present time, with the help of the X-rays, we believe that the diagnosis of small diaphragmatic hernias, which, we repeat, are more frequent than it is commonly thought, and give rise to very serious troubles, has never been made before operation or autopsy. We insist on the frequency and importance of small, very small, diaphragmatic hernias, because unfortunately the subject has received little attention by the internist and the surgeon. This lack of interest is not easily explained, because diaphragmatic hernias give rise to so many complicated and serious symptoms, which if not properly attended to, will lead the patient to an unfortunate life and premature death. That little attention has been paid to the subject of diaphragmatic hernia is proved by the fact that text books, even the ones devoted exclusively to diseases or surgery of the abdomen, either do not even mention the subject of diaphragmatic hernia, or devote only few lines to it. Yet diaphragmatic hernia is a condition requiring immediate surgical intervention, if the patient is to be cured and his life preserved. In fact, if the diagnosis was made at the very beginning, neither congenital nor traumatic or acquired diaphragmatic hernias would cause long useless suffering and later endanger the patient's life, on account of the actual and probable troubles caused by the herniated organs, and the difficulty or even impossibility of performing later a surgical operation, that should cure the patient. Because we have not to forget that at the beginning either a congenital or acquired diaphragmatic hernia is in practically all cases easily operated, while later the mass of the herniated organs increases and might not only be strangulated, but acquire adhesions with the thoracic organs which might render a radical cure difficult or even impossible.

The rather small number of cases of diaphragmatic hernias on record

is not due to their rarity, but to the fact that autopsies are made only on a very small percentage of cases and many patients who might have, and certainly have, died, on account of the presence of a diaphragmatic hernia, have been put on record as deceased not on account of the real disease, but on account of some other pathological condition, because the diagnosis of diaphragmatic hernia had not been made *in vivo*, and the autopsy has not been performed; and even the operating table fails to reveal the presence of diaphragmatic hernias, either because, as our cases will prove, the hernia is not thought of and therefore no operation is performed, or because the diaphragm is not properly inspected: the few small and even large diaphragmatic hernias operated, were not operated because the correct diagnosis had been made, but only because the diaphragmatic hernia was discovered on the operating table, to which the patient had been brought for some other supposed pathological condition: let us not forget the fact, that the diaphragmatic hernia was discovered perhaps only because, on examination of the different organs, they were found all absolutely normal and a very careful search made for the discovery of the cause of the pathological symptoms on account of which the operation was undertaken, revealed accidentally the presence of an opening in the diaphragm; if any pathological condition had been found, that would even most incompletely explain the pathological symptoms, very likely the opening in the diaphragm would have been overlooked and the patient would have had an operation that might have been not only useless, but dangerous. In fact, how many surgeons do inspect the diaphragm when they open the abdomen? I believe very few, exceedingly few, if any, and the writer acknowledges that he himself had never carefully and systematically examined the diaphragm, before he had the opportunity and good luck of observing the cases that will be related later and that convinced him of the unsuspected frequency of diaphragmatic hernias and of the absolute necessity of its diagnosis.

It is obvious, that it is absolutely indispensable to make the correct diagnosis, when even the smallest diaphragmatic hernia is present, in order to treat properly the patient, and not do him harm, as it is done when the diagnosis is not made, as was done in two of our cases. Why is diagnosis of diaphragmatic hernia so seldom made? We believe that two are the main reasons, why diaphragmatic hernias, especially the small ones, are seldom diagnosed: the condition is thought to be very rare; there is not a symptomatology peculiar to diaphragmatic hernias except in the cases of large ones. Let us take up these two points: frequency of diaphragmatic hernia and its symptomatology. That diaphragmatic hernias are much more frequent, than they are thought to be, there is no doubt in our mind about this point, but the internist and the surgeon must think of the possibility of the existence of a small diaphragmatic hernia in all cases suffering from obscure abdominal symptoms, as they think of the possible presence of ulcers, adhesions, kinks,

etc., in order to find more often, than at the present time, that a diaphragmatic hernia is the main or an accessory cause of the troubles complained of by the patients. For the surgeon especially it is very important to think of the possibility of the presence of small diaphragmatic hernias and therefore explore carefully and systematically the diaphragm, in all the cases in which a laparotomy is performed, as he explores all the abdominal organs, *and the diaphragm should be carefully explored also, when other pathological conditions are found, that might explain the symptoms that brought the patient to the surgeon, because of the possible co-existence of diaphragmatic hernias with any other pathological condition*, as will be seen in our cases. We do not insist on this point, because it is too obvious that the patient with a diaphragmatic hernia would not be cured, if the diaphragmatic hernia is not first diagnosed and then properly treated.

Symptomatology.—We have stated that small diaphragmatic hernias are not diagnosed, because they have not a symptomatology of their own: perhaps it would be more correct to state, that we do not know yet a symptomatology peculiar to small diaphragmatic hernias, because not having been diagnosed as pathological entities, the data relating to them have not been properly recorded and collected. When we shall get the habit of thinking of the possibility of the presence of small diaphragmatic hernias, we shall be able to make up a symptomatology peculiar to them, that will lead us to the correct diagnosis, as it happens now in other pathological conditions, that in past years were not diagnosed, because their existence was not known or they were thought to be rare, and in order to make this idea clear, we shall only mention ulcer of the duodenum and appendicitis, the diagnosis of which is made with accuracy at the present time, that we are accustomed to think of their existence and have collected and recorded many important data about them, while in past years, and not many years ago, their diagnosis would have been impossible or exceedingly difficult, and therefore was seldom made. The symptomatology of diaphragmatic hernia is quite complex, because it depends on many factors: the point where the continuity of the diaphragm is broken, the organs that pass through the opening from the abdominal into the thoracic cavity: the portions of these same organs; the relations or adhesions that these organs might contract between the various organs passing through the diaphragm or the organs situated in the thorax, or with the diaphragm itself: the permanence of the herniated organs above the diaphragm: the compression that the diaphragmatic opening might make on the organs herniated: the pulling of the herniated organs on the portions of the same organs that remain in the abdomen: the disturbs that the herniated organs might cause to each single thoracic organ, or to some of them, disturbs which vary according to the position of the patient, that is, whether he is standing or lying down, or on the back, or on the abdomen, or on the left or right

side; to his taking drinks or food, either liquid or solid, cold or warm, to his work, to his emotions, to his temperament. It is sufficient to think of how a diaphragmatic hernia would affect a dispeptic or neurasthenic patient, according to the conditions mentioned above, to make it clear, that it is impossible to fix at the present time a symptomatology peculiar to the existence of a small diaphragmatic hernia. We use intentionally the expression small diaphragmatic hernia, because the large ones are easily diagnosed, when their existence is suspected, by the classical signs of tympanism in the thorax and with the X-rays, and because the small ones are the very ones which give rise to serious troubles, which are wrongly diagnosed and therefore not properly treated, and which are not diagnosed yet even with the help of the X-rays. In fact, while the X-rays are making the diagnosis of large diaphragmatic hernias very plain and easy, they have not given any help in some cases of small ones; on the contrary, they have even lead to a wrong diagnosis, by their supposed and apparent negative findings. Indeed, a small opening in the diaphragm through which a very small portion of the stomach might pass, cannot be diagnosed always with the X-rays, because, when the barium meal fills the stomach, no barium might have entered the herniated portion, or the portion itself at that moment was not herniated, and even the air bulb might not show any appreciable change, or as it has happened, the barium filled portion is mistaken for a diverticulum of the œsophagus. So we can state that the diagnosis of small diaphragmatic hernias can give rise to a complex of symptoms, which at this time cannot be properly classified, because the cases on record are few, and which depend on the conditions we have mentioned above; that not even the X-ray can confirm or deny the existence of small diaphragmatic hernias; that at the present time the proper conduct to follow in regard to diaphragmatic hernia, is to think more of the possibility of its existence, alone or associated with other pathological conditions, and to think of it especially in obscure abdominal cases, where repeated examinations of the different organs and their secretions fail to reveal any conditions that can explain the symptoms complained of by the patient: that the surgeon should examine systematically and carefully the diaphragm in every case in which he performs a laparotomy, especially when he operates on patients with symptoms which are not completely explained with the pathological condition, which he thinks called for operative intervention. These symptoms are quite complex and can go from a feeling of heart-burn that disturbs the digestion, to symptoms related to the heart, to the lungs or both, to the difficulty in taking long breaths, to occasional vomiting, to vomiting occurring after every meal, or only after taking certain kinds of food, or taking either hot or cold drinks; to the most severe symptoms on the part of the stomach, especially when adhesions between the stomach and the opening in the diaphragm take place, or when the stomach is pinched or strangulated by the diaphragmatic open-

ing, to difficulty in swallowing, and to many other disturbs that might arise on account of a special hernia and of the temperament, habits, profession, emotion, age, sex of the patient. How could anyone outline the symptomatology of a small diaphragmatic hernia in a nervous pregnant woman, for instance? We only present the problems arising from all these conditions, because in order to discuss them competently, one should have had the occasion of studying a great number of patients with diaphragmatic hernias; we must and shall feel satisfied, if we have stimulated the medical profession to a more thorough study of the subject and have contributed to develop a rational technic for the complete treatment of diaphragmatic hernia.

That the subject of diaphragmatic hernia is worth of any attention the medical profession might pay to it, is proved by the cases which we report, which although few in number, show clearly that the diagnosis of diaphragmatic hernia would have prevented a useless operation in two cases and in all three it was essential in saving the patient's life.

CASE I.—Miss M. E., aged nineteen, girl poorly developed and rather anæmic. Her history is one of long suffering; dismenorrhœa, constipation, indigestion and severe pain in the abdomen, the nature of which the girl cannot explain better than by saying that she suffers every time she has her menses, that she had once a very severe pain in the right side of her lower abdomen, that she had for a long time a dull pain over there, that she suffers from indigestion and constipation, that at times she can not breathe, that she feels like crying all the time; in fact, she is a rather neurotic subject, discouraged and very melancholic. A year previously she finally submitted to an operation, because of the pain in the stomach and in the lower abdomen, of difficulty in digestion, and occasional vomiting. It seems from the account obtained, that the surgeon did not find anything else but a right ovarian cyst, which was removed and thought to be the cause of all the patient's troubles. For a few weeks after the operation the patient felt better and was greatly encouraged, because her menses were twice much less painful than previously. When she began to try to live a normal life, she felt the same troubles she was suffering before the operation; grew terribly discouraged, because all the doctors she consulted stated that there was nothing the matter with her stomach, that she was nervous and so forth, all putting the cause of her troubles on the nervousness and constipation. When seen by the writer she complained specially of pain in the lower abdomen and pain all over her chest and stomach. Repeated examinations with the X-rays and test meals failed to reveal any pathological condition of the digestive tract, but a certain delay in the emptying of the stomach, and her troubles were attributed by the writer to adhesions that might have formed on the abdominal organs following the operation, and to an exaggerated sensibility and nervousness. We did

not advise another operation, thinking that it would be better to have the girl sent to the country and try to build her up and improve her general condition. The advice was followed and as no improvement was noted, the girl insisted on being operated again and see what was the matter with her. On opening the abdomen along the former incision we noted that there were quite a few adhesions present, the omentum was adherent to the abdominal wall and the right adnexa, the stomach had here and there some very slight adhesions with the abdominal wall; we freed all the organs in which adhesions were found and could find nothing abnormal in any of the abdominal organs. After having freed the anterior surface of the stomach from very slight adhesions easily dissected, we noticed, however, that the small curvature did not come in full view and we thought that there might be some adhesions higher up, in reality the stomach seemed to be adherent to the diaphragm and in trying to free it, we felt that our finger did not meet any resistance and had entered a cavity; at first we feared to have been in the presence of a stomach wall thinned by some pathological process and that we had broken with our fingers, so we gave the patient a slight Trendelenburg and saw instead, that there was a gap in the diaphragm around the œsophagus on the left side. The gap was about three centimetres in length, the stomach was adherent to the edge opposite the œsophagus, and the whole diaphragm appeared rather thinned. The stomach was freed and the gap closed following the technic we shall explain below. The after-treatment was directed to build up the patient and improve the conditions of her bowels. An X-ray examination showed that there was a ptosis of the stomach as shown in Fig. 1. We advised, therefore, the wearing of an abdominal belt, paraffine oil, abdominal massage, and active country life for a long time. At the present writing the conditions of the girl are most excellent, the stomach falls still two fingers' breath below the umbilicus, but that does not seem to affect at all her health and the function of the stomach.

CASE II.—R. G., infantry soldier, had been wounded on the Carso about three months previously to the time he was admitted to our service at the Military Hospital in Vercelli. Nothing worth of notice in the past history. The present history, given war condition, was very scanty, the patient said to have been very ill, and unconscious for several days; he was not operated upon, but kept absolutely still. On examination he showed two wounds, one about two centimetres long on the right of the umbilicus, and another smaller and of irregular form between the eighth and ninth ribs along the scapular line. The wound of the abdomen was healed and showed a scar of irregular form, the one on the back was covered by a scab and was adherent to the eighth rib; the scar on the abdomen was rather painful. The patient complained of difficulty in breathing, of pain all over the abdomen and chest upon any physical exercise or even turning around in the bed, difficulty of digestion and occasional vomiting and constipation. We could not

ascertain whether we had to deal with a patient who had been wounded by one or two bullets; from the appearance of the scars it would have seemed that only one bullet had struck the patient, the bullet entering through the chest and coming out from the abdomen; but war experience has taught us that it is not such an easy matter to determine these facts with accuracy. However, on physical examination and from the few lines of history written on the patient's card, it could be established that the patient had certainly suffered from a severe pleuritis and that drainage of the pleura had been continued for about forty days, a piece of cloth having been extracted from the wound and that the wound of the abdomen had also been drained for several days. As we could not find any bullet or piece of shell, we thought that the wounding agent had been single and had passed from the thorax into the abdomen, and on the basis of the pictures obtained, the one we publish being the most typical, and from numerous X-rays examinations made under the screen, we thought we had to deal with a case of hernia of the small intestine into the lesser peritoneal cavity with probable perforation of the stomach and small intestine, resulting in a stomach being formed between these two organs on the posterior surface of the stomach; we held this opinion, for the fact that the vomiting contained a great quantity of bile, although the only stomach content that we could obtain with the stomach tube did not show any bile; we could not examine repeatedly, as we would have liked to do, the stomach content, because the patient stated that he could not stand the swallowing of the tube, and indeed, we had to discontinue using it, because the patient did really suffer from its use; and we thought that, anyhow, our reasoning was logic and congratulated ourselves on the beautiful and accurate diagnosis we had made. On operation, however, conditions were found to be quite different; there were strong adhesions between the wound, the omentum, the colon and some coils of the small intestine, there were adhesions between the coils of the jejunum, some coils of which were really found in the lesser peritoneal cavity adherent to the posterior surface of the stomach, but without any communication between them; the upper pole of the stomach was adherent to the diaphragm and a portion of it closed a gap in the diaphragm of about three centimetres. All the organs were freed, and the diaphragm closed with the technic we shall explain below. The patient left the hospital in good condition and able to eat and digest easily the ordinary soldier's food, still complaining of slight pain in the thorax and some difficulty in breathing, which naturally can be explained with the wound of the thorax and the following pleuritis.

CASE III.—G. A., infantry soldier, aged twenty-one, nothing in past history, wounded on November 18, 1917, at the left of the xiphoid, no exit of the wounding agent. Patient lost consciousness immediately and was unconscious for about thirty hours: remembers that on regaining consciousness he was loosing great quantities of

blood from the mouth and from the wound, and had continuously the impression of choking, which impression was increased while he had coughing spells, which would bring out more blood from the mouth. Around midnight of the nineteenth he had a more severe spell of coughing and had the impression of being completely choked by something pressing on the inside of his chest and abdomen; he vomited then the food that he had eaten the morning before being wounded, that is, about thirty-eight hours after the food had been eaten. The effort made him faint and when he regained consciousness in the morning he was told that during the night he had been given several injections (probably saline hypodermoclysis and camphorated oil). He began to feel somewhat better, kept loosing blood from the mouth for five days more, and from the wound, which was packed with gauze, for about ten days. The sputum then was mixed with blood for about ten days, and the wound secreted bloody pus. The patient was transferred to a base hospital when the wound healed; was examined with the X-rays, nothing abnormal was found and the patient discharged with a leave of convalescence on the 23rd of December. The patient went home, very weak and pale and kept an almost complete milk diet, because if he ate any solid food he would have feelings of indigestion and heart oppression, relieved only by vomiting. During his stay at home the patient had temperature up to 39.6 so that he went back to the military hospital and the fever continued until about the end of January, 1918. Patient was without fever for two weeks and then had again temperature up to 39 for about 20 days more. He always complained of pain in the abdomen, indigestion, some constipation, some painful cough, and especially of pain around the heart: the pain was so severe, that mustard plasters were applied to the chest over the heart and seemed to have given some relief; the diagnosis made was bronchitis and pleuritis. The patient failing to improve was sent in April to the observation hospital in Milano, where he was thoroughly studied by competent physicians who submitted the patient to the X-rays, which revealed the presence of a small fragment of shell in the upper left region of the abdomen, postums of severe pleuritis and slight dilatation of the heart with cardiopalmus. The patient was given again a convalescence leave of three months, but he returned to the hospital before his furlough was ended, because he could not eat anything solid without vomiting and was loosing flesh and strength, and complained even more than at any previous time of pain in the heart region and inability of doing even the slightest physical exercise. The patient was told that he was too nervous and was advised to take a complete rest, resort to milk diet exclusively and live in the country: he refused to accept the advice, insisting on being admitted to the hospital and undergoing a surgical operation for the removal of the fragment of shell (which he thought was causing all his troubles). He was admitted again to the hospital and in July sent to the surgical division. There the patient was kept several

days and thoroughly examined. The X-rays revealed the presence of a fragment of shell in the upper left side of the abdomen and some abnormalities in the shape of the stomach; so at the end of July the patient was operated by a very competent surgeon, who removed the small fragment of shell of the size and form of a grain of Indian corn, situated between newly formed adhesions behind the small curvature of the stomach, and freed the stomach, which then showed itself quite dilated, from a newly formed band that divided it practically in two halves. The patient failed to get any benefit from the operation, and the physicians in charge in consultation with others, thought that the extreme nervousness and excitability of the patient and probably a paresis of the stomach, due to the wide dilatation found at the operation, were the causes of the present precarious conditions of the patient and though it advisable to perform a gastro-enterostomy, as a drainage operation. The patient having consented to have anything done that would relieve him, it was decided to perform the gastro-enterostomy. The writer saw the patient ready for the operation of gastro-enterostomy in the first Surgical Division of the Ospedale Militare Principale of Milano, while he was substituting the chief of the service Professor Mariotti, to whom he wishes to express his gratitude for having given him all the opportunities to study the case and allowed him to operate on the same, with his invaluable help and assistance.

Before the operation the patient was in exceedingly poor condition, terribly excitable and nervous, and practically a living skeleton. Repeated X-ray examinations made by the writer showed the conditions demonstrated in Fig. 3, and at the operation the condition of the abdominal organs were such as the ones reproduced in the drawings represented in Figs. 4 and 5. The portion of the herniated stomach was slightly adherent to the pericardium and to the edges of the opening in the diaphragm: was freed with blunt and sharp dissection associates and the gap closed with the technic explained in other part of this paper. Recovery uneventful and complete; stomach slightly ptosed; general conditions most satisfactory, the patient having still some slight pain in the chest and slight tachycardia on physical exertions, but feeling otherwise perfectly well and being able to attend to military duties.

COMMENT ON CASES REPORTED

It seems to us that our statements that diaphragmatic hernia is more frequent than it is thought to be, and that its diagnosis is essential for a rational treatment of patients, who might suffer also on account of some other pathological condition, beside the diaphragmatic hernia, are substantiated by the cases reported which seem to us very instructive. In fact, in none of these cases the diaphragmatic hernia had been diagnosed, in two not even at the operation, and in the third one (Case II) was discovered *only accidentally by the writer*, so that all these three cases would have probably ended in death, that would never have been attributed to the exist-



FIG. 1.—X-ray picture of Case I after operation. Only ptosis of the stomach is observed.

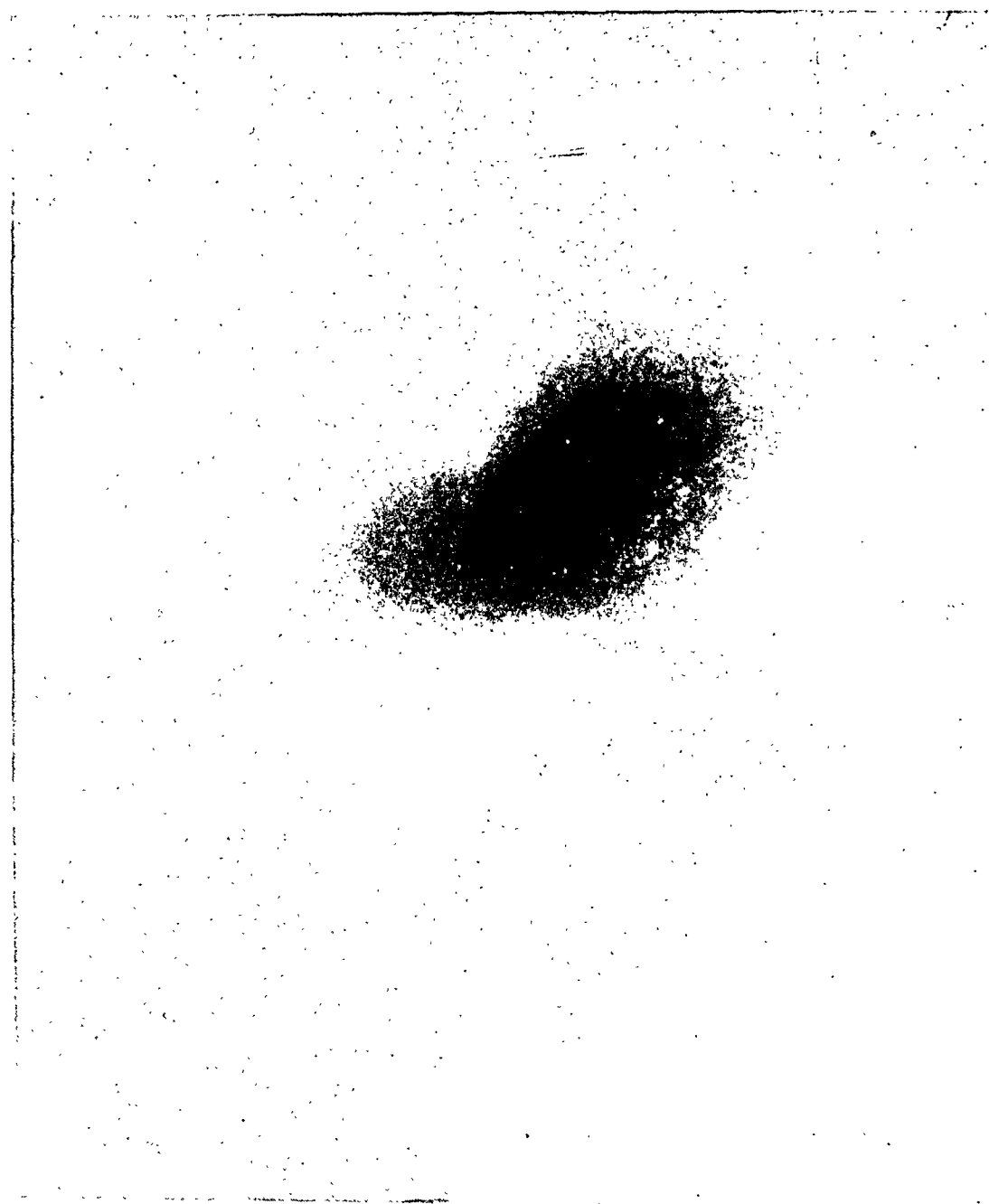


FIG. 2.—X-ray picture of Case II. The small diaphragmatic hernia found at the operation does not appear at all, the picture showing only an intimate union between posterior wall of stomach and jejunum.




FIG. 3.—In this picture is very evident the portion of the stomach that passed through the diaphragm (Case III).

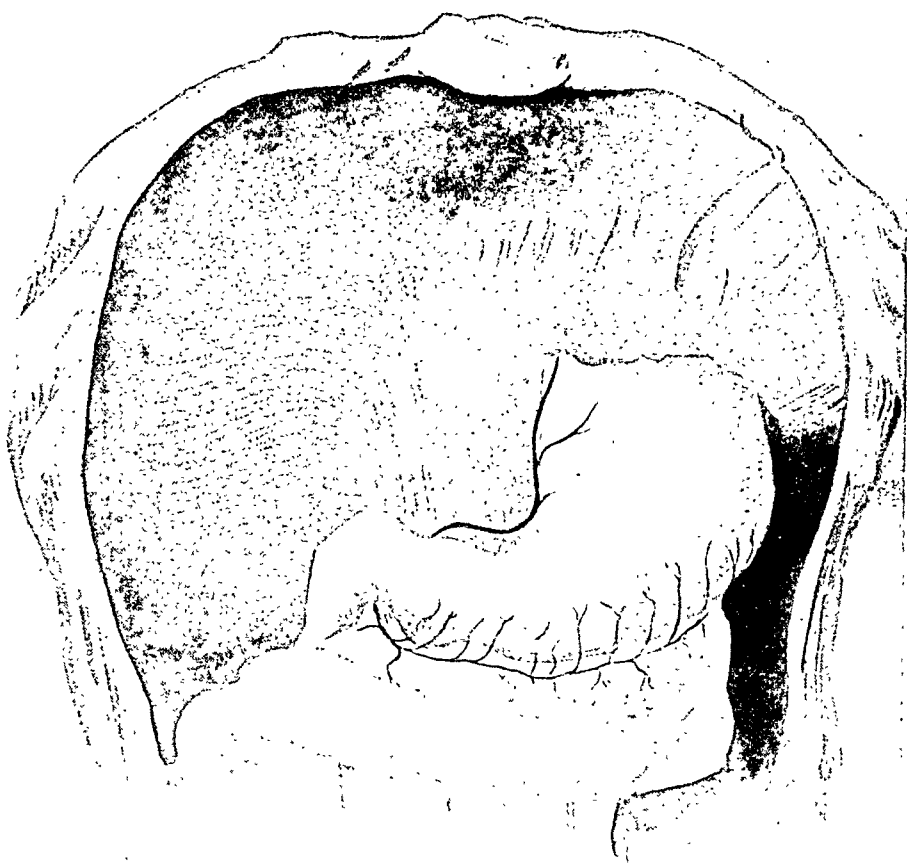


FIG. 4.—Appearance of hernia of portion of the stomach through an opening in the diaphragm.

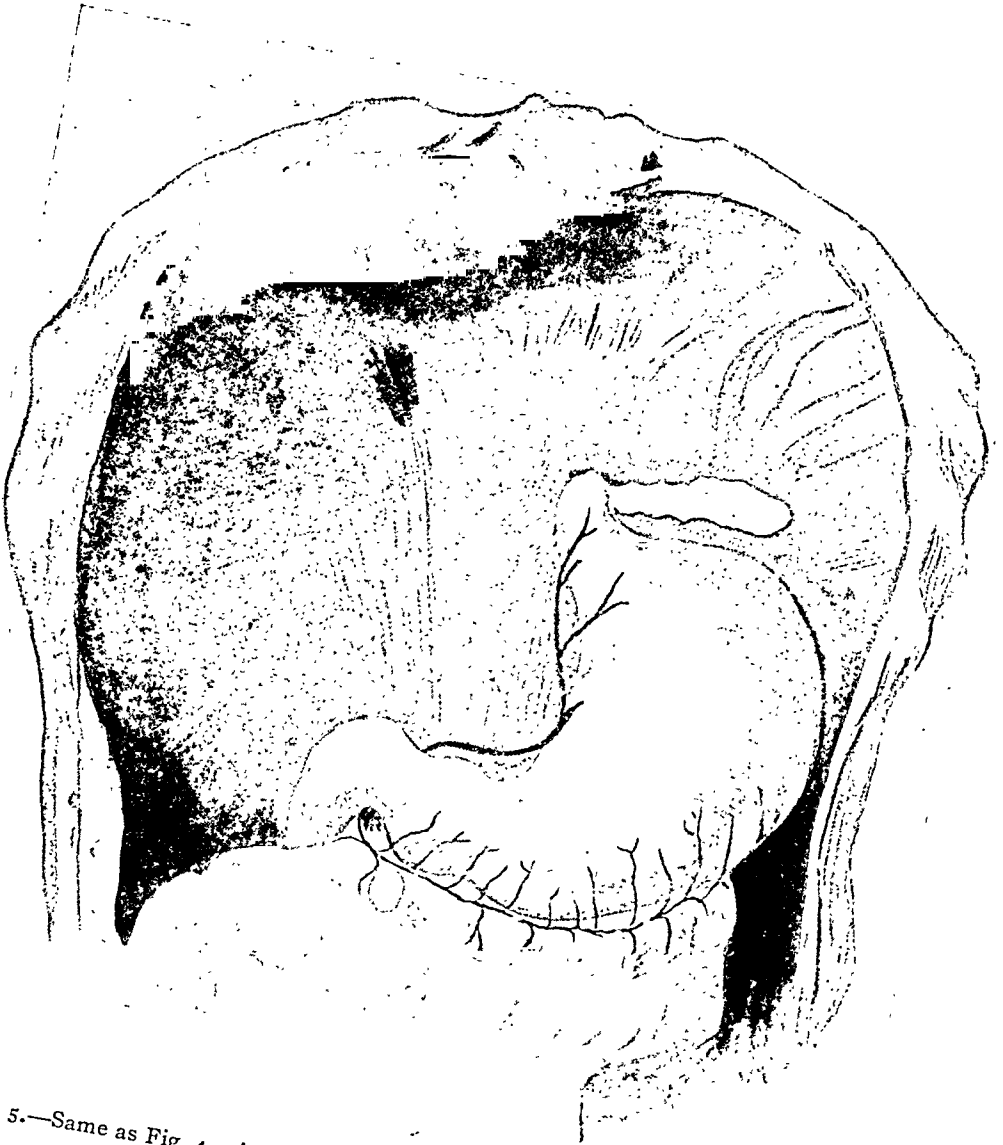


FIG. 5.—Same as Fig. 4, with stomach brought back in the abdominal cavity.

ing diaphragmatic hernia. The second statement, that the diagnosis of diaphragmatic hernia is essential in order to cure patients who might suffer also from other pathological conditions associated with the hernia, and that the surgeon should inspect carefully the diaphragm, when he opens the abdomen, we do not think needs any demonstration, after its absolute necessity is plainly demonstrated by the cases reported. In fact, Cases I and III were physical wrecks, and would have died unless reoperated a second time, and the same could be said of Case II, if his hernia had not been accidentally discovered: Cases I and III had been not only operated upon uselessly, but their troubles were thought to be due to nervousness, exaggerated sensitiveness, neurasthenia and what not; which fact calls for sad reflection on the practical medical science. And we believe that the cases reported are also instructive, because they show that if we have to look for lesions of the diaphragm in all cases in whom there has been a wound around the region of the diaphragm, we should also look for congenital lesions of the diaphragm, which would seem to be also more frequent than we have been thinking.

Varieties of Diaphragmatic Hernias.—Diaphragmatic hernias are either congenital or traumatic, or could result from a collection of pus formed on either side of the diaphragm, that would have destroyed or greatly weakened the diaphragm at the point of its formation. The mechanism by which traumatic diaphragmatic hernias are produced, is easily understood, the diaphragm being torn or cut and the gap resulting from the injury remaining open; or healing imperfectly and then breaking again later.

Congenital hernias do not need to be present at birth; hernias should be considered congenital, when they are formed, because there is a weak point in the diaphragm at birth; this weak point is generally situated around the œsophageal opening; not having the possibility of consulting the literature at the present time on account of war conditions, we do not know if there are on record cases of hernias through the opening for the passage of the aorta or of the vena cava. The diaphragm being formed by the union of several muscles, which merge their tendinous portions toward the centre, hernia might result from any of the points where these muscles and their tendons merge one into the other, either because they do not unite, or because their union being weak, cannot stand the hard work to which the diaphragm is subjected. For obvious reasons diaphragmatic hernias are practically all situated on the left side, because on the right the large mass of the liver forms a kind of protecting pad for the diaphragm. Diaphragmatic hernias differ from other hernias because, for obvious reasons, they are deprived of an enveloping sac.

Diagnosis with the Help of the X-rays.—We have already dealt with the diagnosis of diaphragmatic hernias, we shall only add a few words on the help that the X-rays can lend and how to employ them. When the physician thinks of the presence of a diaphragmatic hernia, a careful

study of the X-rays will in many cases make the diagnosis clear; the herniated organs showing themselves above the diaphragm, these will show more clearly in their pathological position, the larger is the hernia and more voluminous the herniated organs. In small, very small hernias, however, the X-rays will not show any change in the position of the abdominal organs in every case, or and often a diverticulum of the œsophagus will be diagnosed, while one has to deal with a diaphragmatic hernia around the œsophageal opening: in these cases it is sufficient that the physician should think of the possibility of having to deal with a small diaphragmatic hernia, and by examining the patient under different angles and in different positions, might be able to detect the real condition.

When there is suspicion of the existence of a small diaphragmatic hernia that is not revealed by the X-rays examination, we advise the following procedure, which enabled us to make a diagnosis in a case that is not reported, because the patient having refused to be operated, we could not confirm the diagnosis made. The patient is given a mucilage of barium sulphate, made up with syrup of gum or better with tragantha, so as to have a good and uniform suspension of the barium. The patient is examined in the standing position looking at the physician while he drinks the barium mucilage, and the abdomen is massaged: if the hernia does not show itself the patient is examined changing his position from one side to the back, to the other side and again facing the physician. If the examination is still negative, the patient is examined laying on the throcroscope, changing the positions, as done when he was in the standing position; if the examination is still negative, the patient is put on a slight Trendelenburg and instructed to breathe deeply, and then relax the abdominal muscles and by stopping the respiration also relax the diaphragm; if the examination is still negative a massage of the abdomen over the stomach and continued examinations might reveal the presence of the hernia, which had not been seen previously. We advise to follow the technic that we have mentioned, because the barium might not go immediately in the portion of the herniated organ or the organ might not go through the gap at certain moments, and the little hernia is then overlooked, with the added danger to the patient coming from having excluded its existence by an incomplete X-rays examination.

Treatment.—It is obvious that the treatment of diaphragmatic hernia must be surgical; the possible existence of a small or large diaphragmatic hernia is of great interest for both the physician and the surgeon, but once the diagnosis is made or suspected the patient belongs to the domain of surgery. The classical manner of dealing with diaphragmatic hernia is to operate from the chest; we do believe that the chest route should be used only in exceptional cases; the safer and more rational route is the abdominal. In fact, most diaphragmatic hernias will be diagnosed only while operating on abdominal organs, and even if the abdomen had not

been opened, the patient being operated upon through the chest route, the abdomen should be explored in all cases of diaphragmatic hernia, for the possible and probable co-existence of other pathological conditions, either secondary to the hernia or independent from it. It would be a useless and dangerous procedure to open the chest, when the hernia can be completely reduced and its reproduction prevented by operating through the abdomen. The chest route should be reserved for those cases in which the herniated organs have contracted strong adhesions on account of which their liberation is not possible through the abdomen. By the expression their liberation is not possible, we mean to refer to the cases in which the herniated organs have contracted such strong adhesions, that they cannot be freed without causing serious damage either to these same organs, or to the organs with which they have contracted the adhesions. So if the surgeon feels that he cannot easily free the herniated organs without tearing them, or tearing the organs with which they have contracted adhesions, he should stop and open the chest. On the basis of experimental work, we believe that the opening in the diaphragm could be widened in all cases in order to avoid the necessity of opening the chest for the freeing of the herniated organs, because with the technic that we shall describe later, the gap in the diaphragm can be sutured in such a strong and safe manner that there is nothing to fear in widening it. If only slight bleeding should result from breaking the adhesions, the surgeon can do the whole reduction of the herniated organs and the closure of the gap through the abdomen and provide for the drainage of the blood which might ooze out of the lacerated surfaces and collect in the chest, with a stab wound made with a scalpel passed through the diaphragmatic opening and stabbing the chest wall between the two ribs located over the posterior cul de sac of the pleura at its lowest point, and introducing a drainage into the stab wound, which would also provide for the exit of any material that could form on account of the trauma and possible infection of the thoracic organs. If the herniated organs cannot be reduced through the abdomen, the chest is best opened by making an incision of the necessary length through the intercostal space, which will be found to be the most convenient, the ribs being held apart by strong retractors; good retraction will in almost every case avoid the necessity of resecting any ribs. The advantages of the chest and abdominal routes respectively are: by the chest route the whole condition of the herniated organs is seen plainly and can be dealt with in the most thorough and perfect manner; there are in the thorax so many important structures with which the herniated organs can contract adhesions and the freeing of which might be extremely difficult and dangerous, that the importance of the chest route, or better the absolute necessity of resorting to it, cannot be over emphasized when the herniated organs cannot be easily reduced. The advantages of the abdominal route are, that it avoids the necessity of resorting to open widely the

thorax, which procedure, if not as dangerous as it was formerly, is always more dangerous than the opening of the abdomen, which, as said above, should also be opened anyhow, in every case of diaphragmatic hernia, in order to examine the conditions of the abdominal organs and repair any pathological condition that might be present in the abdomen.

In difficult cases the chest and abdominal route can be advantageously associated, the freeing and reduction of the herniated organs being done by the harmonious work of the surgeon and his assistant, as is done, for instance, in some cases of combined abdominal and vaginal or abdominal and perineal work.

We shall not dwell on the general technic of dealing with a diaphragmatic hernia, the operation, however, should be reserved to men who are masters of surgical technic and not to beginners or to amateurs, the difficulties that can arise might require the greatest coolness and mastery of every detail of technic. We only shall spend few words on the technic of freeing the herniated organs.

The main dangers in freeing the herniated organs come from possible shock and laceration of important structures. Shock can be reduced to a minimum or prevented almost completely by avoiding any pulling on the organs that are herniated and on the organs to which the herniated organs are adherent, by operating rapidly and with perfect technic, and by avoiding all unnecessary traumata. The organs which might have contracted strong adhesion must be freed by clean and sharp dissection and not by tearing the adhesions with the finger; clean and sharp dissection done with perfect technic will avoid laceration, unnecessary trauma and pulling of such delicate and important structures as the pericardium, pleura, lungs, œsophagus, diaphragm, stomach, blood-vessels, nerves, intestines, etc. The dissection should always be carried on in such a manner that the less important and more easily repaired organs might be injured; that is, for instance, given strong adhesions between the stomach and the pericardium, œsophagus, etc. The dissection is made very close to the stomach, which even if it should be accidentally opened, can safely and rapidly be closed and repaired. To do this work satisfactorily long incisions are indispensable: they give not only more room but allow a better view of the different organs, which must be under the complete control of the operator, if unforeseen and perhaps fatal accidents have to be not only prevented, but possibly repaired, if they should occur, notwithstanding all the precautions the surgeon might have taken. Full view of the organs concerned in an operation for diaphragmatic hernia, is best obtained by giving the patient the Trendelenburg position, when the operation is performed through the abdomen, and putting a pillow under the side of the chest that is not operated upon, in order to widen the intercostal space as much as possible, when the operation is performed by the chest route. The best manner of illuminating the operative field is the use of a frontal lamp, with which the surgeon can really

throw the light where it is needed and avoids the encumbrance caused by lamp post or by the person holding the lamp; we believe the front lamp to be almost indispensable in order to operate in the very best manner on the diaphragm.

Closure of the Opening in the Diaphragm.—The safe and perfect closure of the opening in the diaphragm is obviously of the utmost importance: the suture that is used in approximating the two edges of the opening has to fulfil the following indications: it has to approximate very closely, without tearing them, the edges of the opening; the suture should prevent tearing of the diaphragm later; the suture has to close in the most perfect manner the opening of the diaphragm, especially around the organs that pass through it, œsophagus, cava, aorta, nerves, when the opening is found around them, but without compressing the important organs just mentioned; the suture should not cause the perforation or inclusion in the suture itself of any thoracic organs; the suture should strengthen, if possible, the sutured portion of the diaphragm.

The importance of these points cannot be over emphasized: the diaphragm is a compound of several muscle bundles which unite forming a broad, central, strong tendon; the diaphragm on account of its important function cannot stop its work, when the opening that resulted in the formation of the diaphragmatic hernia is sutured, *the edges have to adhere and form strong and permanent adhesions, not while the diaphragm is at rest, as it could and does happen in other parts of the body which can be put at rest, but while the diaphragm is working.* To emphasize the importance of this point, we can compare the healing of the sutured parts making up, for instance, an epigastric or an inguinal hernia or still better a hernia in the abdominal walls secondary to a laparotomy: the ordinary suture would hold very seldom if the patient immediately after the operation, was not put in a position of complete rest and kept there for several days, but was compelled to strain the sutured structures without a moment rest. And the importance of a complete healing and formation of strong union between the edges of the opening in the diaphragm is also made evident by the fact, that if strong union does not take place, a second operation will be necessary; operation to which the patient might object, thinking that the surgeon who has not cured him at the first operation, did not know what his ailment was, or was a poor surgeon, or distrusting all together the ability of surgical science to effect a cure. This last point is very important, because, as we have said before, the diagnosis of diaphragmatic hernia is only seldom made, especially when the hernia is very small and so the patients suffering from it are not properly treated and go from one doctor to another and when finally they are operated upon, if they are not cured, they will loose all confidence in medical and surgical science, and be physical wrecks for life.

The ordinary suture does not close completely the opening in the diaphragm without leaving any gap between the stitches and through

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these small gaps the abdominal organs could pass again in the thorax; this is especially true of the gap that is left around the œsophageal foramen, through which the stomach can easily find a way into the thorax again, if it is not most completely and securely occluded. The importance of occluding even the smallest gap, so that the diaphragm has to appear and be a strong uninterrupted structure, is understood, when we consider what we said previously of the continuous uninterrupted working of the diaphragm, which might, and in all probability will, cause any small opening to widen, but certainly not to get narrower and finally become occluded. The importance of not compressing any structure, that is included in the closing of the gap formed in the diaphragm, has only to be mentioned to be appreciated, and the same thing can be said about injury of any thoracic organ. The ordinary suture does not strengthen the diaphragm along the suture line; on the contrary, it weakens it, and the importance of strengthening the suture line is plain, when we think that diaphragmatic hernias either congenital or acquired result always from the fact that the diaphragm became weak or its continuity was interrupted at the point where the hernia has formed, so that this point must be made as strong as it is possible to make it. We hope that the suture we have devised, and that we use also in epigastric hernias, and in hernias of the abdominal wall, will be found useful in the diaphragmatic hernias by other surgeons, as it was found useful and serviceable by us.

Suturing of the Diaphragm.—The suture we recommend because we have found it to be most satisfactory both in clinical and experimental work aims to approximate the edges very closely, in fact, it overlaps them, and to keep them closely approximated. The stitches are put in such a manner, that they cannot tear the tissues, but can stand any amount of strain from the very moment they are put in. In this manner the continuous hard work made by the diaphragm, can be done without fearing that the suture might cut the structures which it has united. Our suture closes up the corners of the gap securely and completely; in fact, we think that it fulfils all the conditions we believe to be essential for a good suture of the diaphragm. The illustrations show plainly how the suture is applied; silk, preferably black, is threaded on a curved needle, the index finger is passed under the edge (Fig. 6) and the needle takes a bite parallel with the edge of about three or four millimetres, the two ends of the thread are caught with an artery forceps. Another stitch is taken along side of the first one and so on until sufficient stitches have been put on both edges (Fig. 7). The corners are dealt with in the following manner: The needle enters the edge under its middle and makes a kind of purse-string suture around the edge, coming out close to the last stitch (Figs. 7, 10 and 11); the same thing is done with another needle in the opposite direction. When all these stitches have been placed (Fig. 7) we have before us a series of stitches parallel to the cut edges: the next

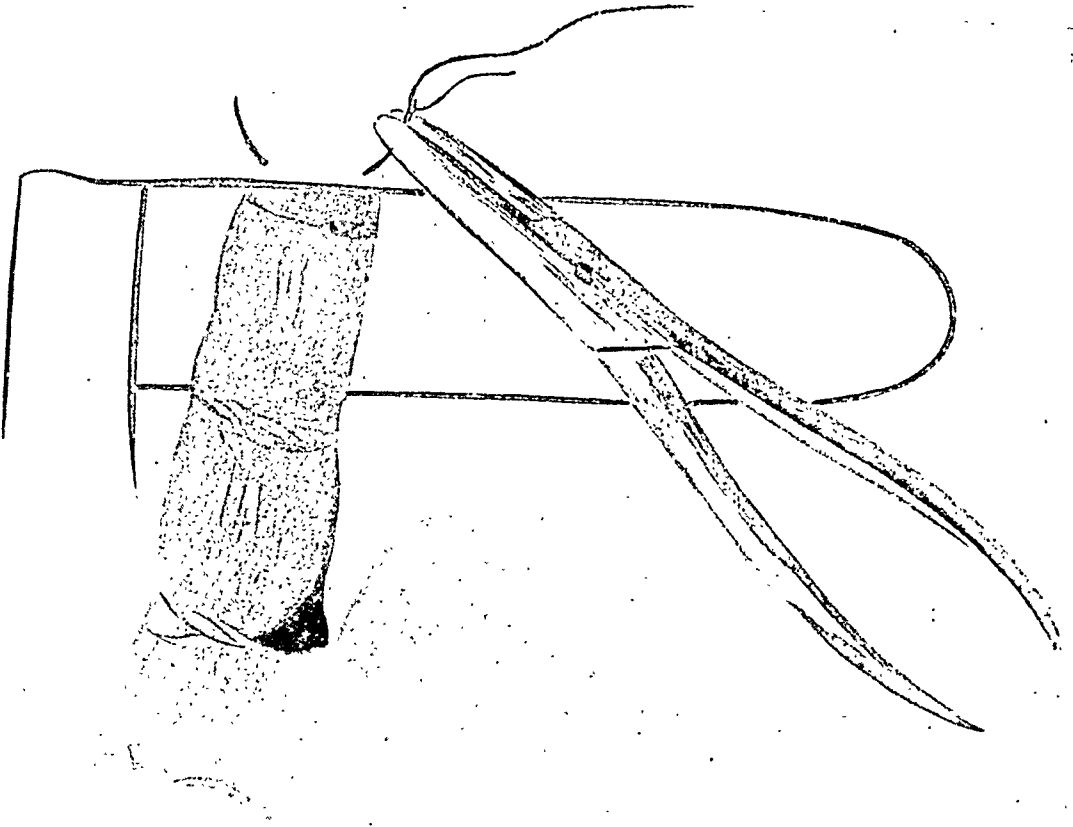


FIG. 6.—Manner of putting sutures that will close the gap in the diaphragm: the index finger preventing any organ to be included in the suture.

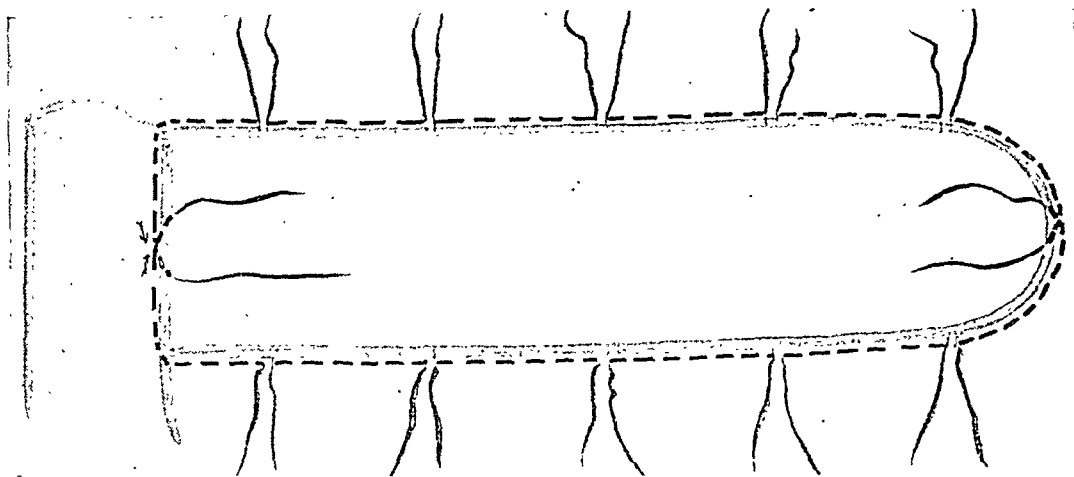


FIG. 7.—Stitches placed all around opening in the diaphragm.

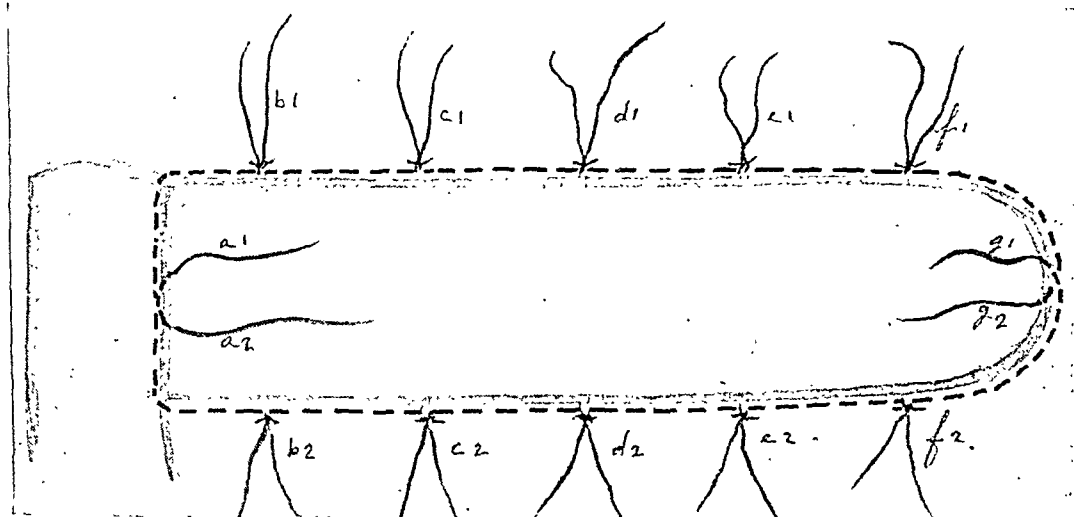


FIG. 8.—Stitches being tied to each other, each thread tied with its neighbor.

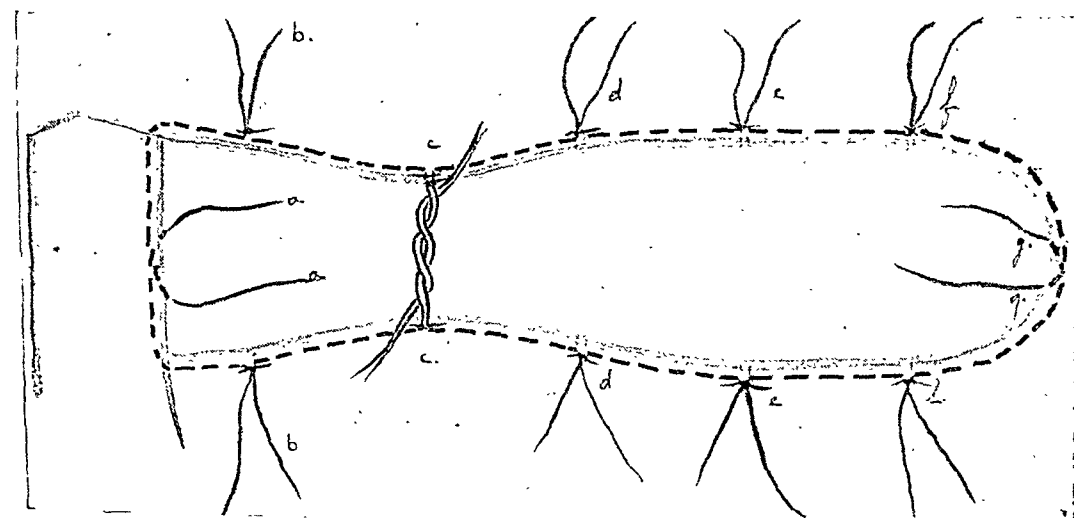


FIG. 9.—Closing gap in the diaphragm by tying together stitches opposite to each other, a with a, b with b, c with c, etc.

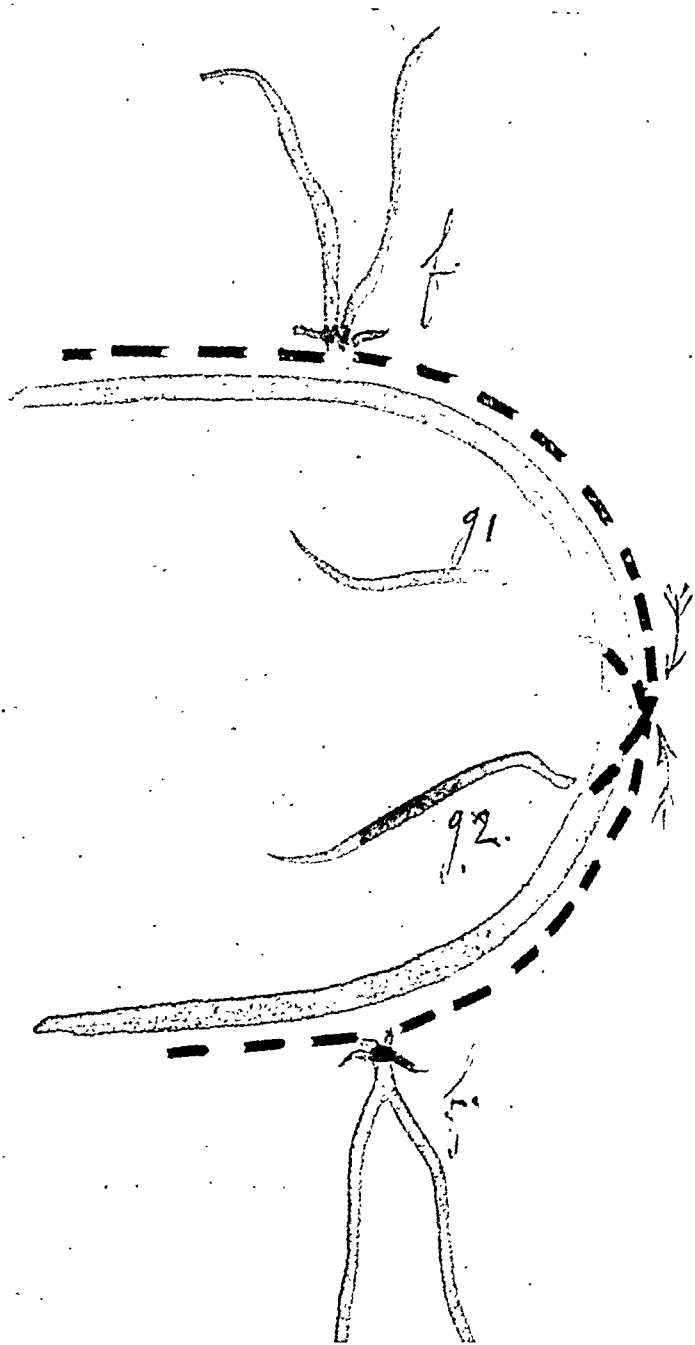


FIG. 10.—Details of how to close corners—note how threads *g1* and *g2* overlap each other, so that when they are tied they approximate securely the parts that have been sutured.

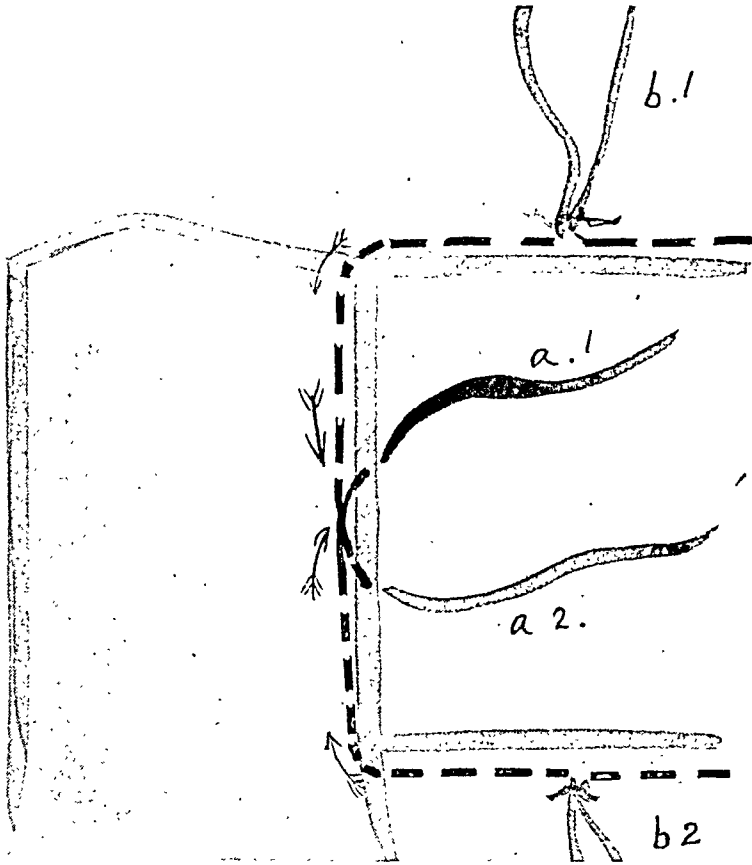


FIG. 11.—Details of how to close diaphragm around œsophagus, threads *a1* and *a2* enter the superficial layers of the œsophagus and are pulled and tied together after stitches *b1* and *b2* have been tied, so as to occlude completely the gap around the œsophagus; for clearness illustration shows threads entering the lumen, in actual operation this will not happen, if only superficial layers are interested with the suture.

step is the tying of the ends of the stitches which emerge near each other on either side of the gap (Fig. 8). When all the ends of the threads have been tied, all the stitches form a kind of continuous line on each side of the gap, which is then closed in the following easy manner. The ends of the stitches that have been tied together, are tied again with the ends of the stitches of the opposite side (Fig. 9) and the two corners are also securely closed by tying the ends of the stitches that were put around them (Fig. 10).

If the œsophagus or the cava or the aorta are found in the gap of the diaphragm the stitch is somewhat modified, the needle goes through the most superficial layer of the organ that is included in the gap, as shown in the illustration (Fig. 11). Naturally the surgeon must be exceedingly careful in not entering the lumen of the organ, it is sufficient to take in only the very most superficial layer of the organ in order to obtain a perfect closure of the diaphragm around it; in our clinical work we had only the occasion to suture the diaphragm around the œsophagus, but we tried to suture it around the aorta in some experimental work and the results were absolutely perfect. Anyhow, around the organs included in the area, where the hernia is formed, there is always some amount of scar tissue through which the needle can be passed with perfect safety, without any fear of entering the lumen.

It is seen that with the suture we have devised, the gap in the diaphragm is securely closed and no strain is put on any single stitch, the suture being made by single threads which form a continuous line on each side of the gap and pull together without the possibility of cutting the parts that have been sutured, the tension being not on any single stitch, but on the whole line. We recommend the use of black silk, because it is more easy to place properly the stitches, if the silk is black and therefore easily distinguished from the surrounding tissues, than if material of neutral color, such as plain silk, was used; we prefer silk to catgut, because silk will not be absorbed, is incised in the scar tissue and therefore renders the scar stronger.

After-treatment.—Although the suture we have recommended is strong enough to stand any strain, it will be preferable to instruct the patient to breathe with his chest, so as to strain as little as possible the diaphragm. The patient can be fed as soon as he feels like taking food, but it is advisable not to give any drink or any food until the surgeon is sure that the patient shall not vomit, because naturally vomiting will put a great strain on the diaphragm, strain that can be avoided by withholding drinks and food until the patient shall not vomit. This point is more important in cases of congenital hernias due to weakness in the structure of the diaphragm, because the suture cannot make the tissues stronger than they are naturally, and if the suture is made on tissues with little resistance, it is obvious that the suture might hold, but that the tissues might tear, if too much strain is put on them, and therefore it is advisable to

avoid all unnecessary strain. The patient should be kept in the position that he finds to be the most comfortable, so as to allow the greatest ease in breathing and should get up when he feels that he can breathe without any discomfort.

We may be allowed to suggest a very comfortable dressing that we use in all our laparotomy cases, and which was found especially useful and comfortable in our cases of diaphragmatic hernias. Before the operation we have the patient wear for a few days, when this is possible, a well-fitting, elastic abdominal belt; when the operation is completed we dress the wound in the following manner: we put several layers of gauze over the sutured wound and apply on the abdomen the elastic belt. We do not believe that there is a more rational and comfortable dressing, especially if the patient has been accustomed to wear his belt for a few days previous to the operation. Patients who had been operated twice on the abdomen declared that the comfort they experienced with the simple dressing made with the belt was really wonderful, and comparing the feelings of uneasiness and in some cases of real suffering caused by the other dressings now in use, they all declared that the elastic belt had robbed the operation of some of its most unpleasant features. We advise the patient to wear the abdominal belt for some time at least, because it seems that the stomach has a tendency to fall down in the abdominal cavity, as we have clearly seen in our cases. After a certain time, abdominal massage and deep breathing exercises will be found very useful.

In conclusion we shall recommend again to look for the small diaphragmatic hernias, to persist with the X-ray examinations, when there is some doubt about the probable existence of the hernia, and to inspect carefully the diaphragm in all cases in which a laparotomy is performed in order not to overlook existing diaphragmatic hernias, remembering, that the smaller they are, the more easily they can be overlooked and will give rise to obscure symptoms, which might render quite uncomfortable the patient's life, unless the hernia is properly operated upon.

We believe that the diagnosis is made more easy and the operation best performed if the indications given above are followed.

GAS AND THE MOTILITY OF THE SURGICAL STOMACH *

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A CERTAIN amount of gas undoubtedly always exists in the normal stomach although there may be no consciousness of its being there and there is obviously a purposeful relationship between this intragastric gas and the stomach's motility. Throughout the stomach and intestinal tract this contained gas apparently becomes an almost indispensable medium for the origination and perpetuation of the peristaltic contractions and for the coördination of the colonic, enteric and gastric waves with one another. Whenever an irritable focus arises at any site along this visceral tract or in any coördinated system of intra-abdominal organs the whole functional picture changes, and particularly the expression of the stomach's activity. Under these conditions, intragastric gas, although it may not have increased in quantity, becomes superfluous and often burdensome and, by the patient, is blamed as the immediate cause of his illness.

The question of vagotonia and sympathicotonia is again brought up in the discussion of the surgical stomach. The objections to this nomenclature are: (1) The innervations by the autonomous and sympathetic fibres are not understood, much less generally agreed upon; and (2) it needlessly revives the fundamental consideration of the origins of disease: whether disease is purely functional and then morphological or whether morphological and then functional. The solution of the etiology of disease is a philosophical one and peculiar to each individual. Surgery is concerned with the elimination of the functional disorders and applies itself to the material causes of disease. The stomachs described in this paper can only act in their own terms if they act at all. Certain stimuli are set in motion by producing diseased conditions of the appendix, gall-bladder, duodenum, or stomach, and the stomach responds with changes in motility. It is not improbable that purely chemical causes may bring about diseased conditions in these organs, that the physiology of the organs of internal secretion may have allowed these chemical causes to work harm to the individual, and, even more remotely, that inheritance may have been responsible for the insufficiencies of certain ductless

* This paper was undertaken to answer questions that have come up in the course of surgical teaching; such as, "Why hypermotility in some instances and pylorospasm in others of chronic appendicitis?" "Why epigastric cramp in gall-bladder disease?" "What gives rise to the incisura in the normal stomach?" "The significance of gas in stomach contraction?" etc.

glands, but, in the rational treatment of morbid processes, one has to start somewhere and surgery elects to attack the material causes.

However responsive the stomach's behavior may be to disturbances elsewhere within the abdominal cavity it does not appear that relaxation and dilation will progress to dangerous limits. The few and isolated cases reported seem to be instances in which the structure of the stomach has been impaired. Gill's¹ case apparently comes the nearest being a real spontaneous rupture of a normal stomach, but even here, during the forty-eight hours of gastric dilation, two doses of atropin had been administered. The responsive nausea, the possibilities of personal idiosyncrasy and of selective drug action are so great that a negligible depressive action of the drug can scarcely be excluded. Batelli,² in 1896, showed that atropin may be followed by a loss in gastric tonus and contractions, in vagus excitability, and in splanchnic action. A normal stomach is protected against dangerous distention by eructation and vomiting.

The origin of the stomach gas is in doubt. The possibilities are obviously air that has been swallowed, duodenal gas that has been eructated through the pylorus, as bile and duodenal secretions are eructated, or, finally, an end-product of stomach chemistry or of gastric metabolism. The analyses of stomach gas correspond with those of expired air and this similarity suggests atmospheric air as its basis.

The functional significance of this gastric gas has been studied clinically as well as experimentally. From recent surgical writings, it is apparent that observations are being made during clinical operations upon the motility of the stomach, intestine and ureter. The common bile-duct belongs in the same category of hollow viscera but its peristalsis is probably still of physiological interest only. Ureteral peristalsis has been called attention to as a convenient means of differentiating the ureter from a blood-vessel. Gastrosplasm and enterospasm are frequently seen after handling these organs in the human subject, and gastric peristalsis has often been displayed and its relationship to peritoneal traumata brought out in clinical teaching. The pyloric and ileocolic sphincters, under the same nervous control as the rest of the hollow viscera, are frequently investigated in respect to size and tone. It is probable that these findings very well correspond with the fluoroscopic and X-ray studies as well as with the observations upon experimental animals. This is very important because it makes possible more prolonged and better controlled studies of human surgical problems upon brute animals.

In order to bring out the relationship of stomach gas pressure to stomach contractions, four experiments were performed upon the canine stomach during the digestive period and under morphine-ether narcosis. The intragastric tension was measured in millimetres of water on a manometer connected up with the anterior wall of the stomach. The traumatization of introducing the canula tip increased the force and, pos-

sibly, the rate of the peristaltic contractions for the first few seconds but the waves continued on by the canula to the pylorus. Air, forced into the stomach, raised the pressure of the contained air and registered on the manometer.

Experiment 207.—A normal two-cycle stomach with peristaltic contractions recurring every twenty seconds and with an intragastric pressure of 30 mm. Each respiration raised the pressure 10–20 mm. and each prostaltic wave 5–15 mm. The greatest rise occurred at the time the proximal wave was at the pylorofundic junction and the distal one was at the pyloric sphincter.

The pressure was raised from 30 to 90 and the variations ranged between 85 and 100; these variations were respiratory only for the peristalsis had disappeared.

The pressure was lowered to 70, to 60, to 50 and to 40, successively, before peristalsis was observed again in the stomach. When reduced to the normal 30 the waves appeared as above with the same periodicity but with slightly reduced force.

There was heard at this time and through the remainder of the experiment a distinct pyloric rumbling, fairly low-pitched, synchronous with the appearance of the through-prostaltic wave at the pylorus.

The stomach was emptied of its gas, and, while the contractions continued every 20 sec., they were weak, and the gurgling disappeared.

At 15 and 25, the soufflé reappeared. At 50, the motility was pyloric, with an occasional through-wave and gurgling. At 70, 80 and 130, "through" waves persisted, but with irregularity in rhythm and force, and the intrinsic pyloric motility had disappeared. Respirations continued to exert their influence, very strong inspiratory efforts forcing the water out of the manometer.

Conclusion.—Waves of gastric contractions persist during a given activity period whether the intragastric air pressure is normal: 30, hyponormal: 15, zero, or greatly increased: 70, 80, 130. In a normal animal the strongest contractions appear to coincide with the normal intragastric gas pressure, 30.

These findings agree with those of Cannon³ on the cat, the conclusions of which, he summarizes as follows: "Gastric peristalsis results from tension produced by internal pressure acting on the tonically shortened gastric musculature, for (1) distention of the inactive stomach causes peristalsis when the musculature is tonically shortened but not when it is relaxed; (2) considerable intragastric pressure (sustained tension) prevails in the stomach manifesting peristalsis; (3) within limits peristalsis is augmented or weakened as intragastric pressure is experimentally increased or decreased."

Surgery recognizes two points in intragastric pressure: that which exceeds the physiological limit and that which falls below that limit. The former is known as dilation of the stomach and the latter is a partially collapsed stomach occurring in perforating ulcer and traumatic rupture. From the above observations, it appears that the motility is diminished whether the pressure is abnormally high or low. In acute dilation and in perforating ulcer the immediate treatment outweighs all other considerations, but in the chronic stomachs with abnormal pressures and abnormal motility, the treatment of the causes of these distentions or motor changes is desirable.

The etiological treatment of dilation, whether prolonged as in mechanical closure of the pylorus or spasmodic as in the so-called "stomach-reflex" conditions, involves the study of a great number of possible causal factors. Whatever the origin of the gastric spasms, whether they be "reflex" or due to changes in intravisceral pressure (Cannon), or due to changes in the gradient of contractility (Alvarez⁴), or whether the spasms depend upon one or more of these conditions as associated factors, symptoms of distention are complained of by the patient and abnormal motility is observed by the examiner. The motility may be increased, decreased, reversed, or spasmodic.

The significance of pylorospasm differs with the conception of "pylorus." If by "pylorus" is meant the projecting edge of the pyloric end of the stomach into the duodenum, then pylorospasm is limited to an arbitrarily small segment of the stomach. If by "pylorus" is meant the pyloric end of the stomach or the "surgical pylorus," then pylorospasm becomes a diffuse spastic contraction and is qualitatively identical with hypermotility. The former is of myogenic origin⁵ and of the nature of gastrospasm and the latter rises from irritation from within and from without the stomach as well.

Of the three physiologic portions of the stomach: the *canalis gastricus*, the *saccular fundus*, and the active pylorus, the pylorus, comprising the greater part of the organ that appears horizontally at laparotomy, is principally concerned in hypermotility. Fright stirs up very active peristalsis; so do appendicitis, duodenal ulcer, gall-bladder disease and lesions of the stomach itself: ulcer and cancer. Graham⁶ writes that "bloating and pressure are more common in gastric than in duodenal ulcer," while in gall-stones "the gas present intensifies the distress and belching gives short relief." In these conditions, the irritation may be so intense as to convert hyperperistalsis into gastrospasm with retention instead of early emptying as the clinical manifestation. These phenomena account for the pain which Carlson⁷ has associated with the gastric contractions and also for the abdominal distention.

Experiment II.—Fasting stomach corresponding to stomach of patient "prepared" for operation. Stomach powerfully contractile, with loud pyloric soufflé and of three cycle type.

(1) Index finger extended beneath lower angle of wound over parietal peritoneum as though about to raise the angle of wound for inspection. Result: Dilation of stomach, with absence of contractions for a few seconds, normal prostalsis and pylorospasm.

(2) Cæcum (appendix) clamped and released. Result: Dilation of stomach, with absence of contractions for three min., normal prostalsis and pylorospasm, slight irregularity in time and force.

(3) Gall-bladder clamped and released. Result: Dilation of stomach, with absence of peristalsis for three min., prostalsis and pylorospasm, increased irregularity in rate and increased force.

(4) Stomach at lesser curvature of pyloric region clamped and released. Result: Dilation and no contraction for a few seconds; strong retrostalsis beginning at pylorus

GAS AND THE MOTILITY OF THE SURGICAL STOMACH

and progressing orderly to pylorofundic junction where the contractions disappear. (In the voluntary animal this would probably be accompanied by vomiting. This reversed peristalsis is therefore to be regarded as purposeful: as an effort to remove the irritation through the mouth.)

Conclusion.—Appendix and gall-bladder diseases are associated with hypermotility, including pylorospasm. Pyloric disease gives rise to reversed peristalsis.

From the above experiment it appears that relaxation and contraction of involuntary muscle are balanced against each other very much as they are in voluntary muscle. Peritoneal traumata appear to cause cessation of the stomach's contractions and stimuli from the intestinal tract seem to start the contractions up again. There are doubtless innumerable extraneous causes of gastric hypermotility, and these experiments are significant in that they depict as possibilities certain common surgical findings in the human abdomen.

Similarly in three out of five animals trauma to the gall-bladder was followed by retrostalsis in the stomach and in the remaining two by forcible prostalsis or hyperperistalsis. These findings again correspond with the vomiting and epigastric cramp of gall-bladder disease. Clamping of the ureter is more difficult and necessitates a greater amount of peritoneal trauma which, in turn, is followed by a longer atonic gastric phase and the stomach contractions, when they do appear, are diminished normal (two experiments). Clamping of the pancreatic duct has been followed in one case by intense stomach cramp. Disturbances in the stomach and duodenum, due to diseased foci in other organs, differ from disturbances following localized lesions in the stomach and duodenum in this respect: that in the former instance there is general hypermotility, pylorospasm, or duodenospasm and in the latter there may be hypermotility but there is more likely to be localized gastrosphasm or duodenospasm. In both types of stomachs and duodeni, there may be hypertonicity and hyperperistalsis, although in a few instances there are hypotonicity and diminished or absent peristalsis, but segmental spasm or the incisura is particularly characteristic of the localized lesion.

In subacute and chronic conditions the duration of the exciting cause: appendix, gall-bladder, or duodenal ulcer, implies that so long as the stomach remains anatomically normal it must repeatedly manifest hypermotility and pylorospasm. Röntgenographic evidences of hyperperistaltic stomachs in these cases as well as occasional accidental inspections of hypermotile stomachs in the operative room support this view. Indeed, it is quite generally agreed that the rule in individuals with chronic appendicitis is not only a hypermotile but a hyperfunctionating stomach inasmuch as hyperacidity is often associated with hypermotility.

Gastrosphasm includes spasms of any part or of the whole of the organ. There may be spasmodic contractions of the cardiac or pyloric sphincters, segmental contractions appearing as incisuras, diffuse contractions of the pyloric ends, or total gastrosphasm. Tetanic contractions of the

sphincters and the "incisuras" are, in surgical cases at least, often indications of local lesions, while diffuse and total spasms are probably qualitatively the same as hypermotility in most cases.

Cardiospasm is probably protective and occurs when the stomach's condition is unfit to receive food. This would correspond with Cannon's findings for the small gut in the presence of caudal obstruction. It follows that local irritation plays an etiological part in the surgical spasm of the cardia. This relationship was illustrated in a personal experience with cardiospasm which was associated with a pin imbedded in the parietal peritoneum and upper left abdominal rectus muscle sheath and which was relieved by the removal of that pin, and also in the suggestive case of Carman⁸ and Miller in which duodenal ulcer was found two years after securing partial relief of the spasm by forcible dilation. It is possible that irritation from other parts of the abdomen may give rise to cardiospasm. This is supported by the anatomical researches of Keith⁹ on the nodal significance of the cardia, by the heightened irritability described for the cardia by Alvarez,¹⁰ and by the frequency of cardiospasm in high-strung nervous individuals.

Many writers contend the absence of peristalsis follows pathologic conditions of the ileocolic region in support of the so-called ileopyloric reflex. White¹¹ found that the motor effects of the stomach vary with the degrees of cæcal irritation, that these effects may be reversed peristalsis, pylorospasm, and hypermotility to no effects at all. This agrees with personal studies on the two ends of the small gut in which it appeared that the contractility of the duodenum varies with the end-resistance or obstructive irritation of the ileum.¹² The most frequent failure in motility, clinically met with, is that associated with the fatigue or atrophy of gastroparesis or, in other words, in those individuals of lowered general resistance who often have diminished gastric tone. Dilation follows prolonged pyloric stenosis. Personal experiments herein reported and to be published in a subsequent paper have not found splanchnic inhibition to be vitally concerned in gastric dilation, but they have shown a fairly constant cessation of the gastric contractile waves and gastric relaxation after rubbing of the parietal peritoneum or handling of the viscera which does suggest some form of nervous arc over which inhibiting impulses may travel. Furthermore, it appears that there is a fair constancy in the promptness of dilation succeeding traumata, in the duration of the dilation, and in the tendency of the stomach to remain dilated as the traumata are repeated or prolonged. It is extremely probable that the post-operative dilation of the stomach and that ileus are of this nature.

The phenomenon of reversed peristalsis is a part of normal physiology and when carried to excess is observed pathologically in thin-walled abdomens with pyloric stenosis and dilated stomachs. It may be confined to the pyloric end of the stomach and may continue while regu-

lar prostatic waves are seen coming from the cardia; or retrostatic waves from pylorus to cardia may occur alone. The protective function of anastalsis is manifested in the vomiting of acute toxæmias and obstructions.

Summary.—Atmospheric air serves as a basis for stomach gas. Gastric air tends to preserve normal intragastric tension at which the stomach contracts most effectually but above and below which the contractions fall off. Spontaneous rupture of the normal stomach is probably unknown. In dilated stomach the gas accumulates in abnormal amounts and correspondingly influences gastric peristalsis. The cause of chronically disturbed stomachs may lie in diseased appendices, gall-bladders, duodeni, or in other organs. Diseases of the stomach, appendix, gall-bladder, and duodenum may be associated with gastric hypermotility and pylorospasm. Contractions of the stomach and of the intestine occur, under certain conditions, in the open surgical abdomen and appear to be influenced by parietal and visceral traumata. Irritation of the parietal peritoneum appears to inhibit the stomach's motility; irritation of the abdominal organs by handling or instrumentation may stimulate or depress the motor functions of the stomach according to the degree of irritation.

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FATTY HERNIAS

WITH A REPORT OF A CASE OF STRANGULATED FATTY HERNIA ENVELOPING AN EMPTY FEMORAL SAC

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BEFORE describing this case, I wish to take up the subject in a general way in order to draw the attention of surgeons to this rare or rather, perhaps, neglected field.

After reviewing the literature of the subject which contain only a few, but fortunately most excellent papers; I am inclined to think that the condition is not so rare as would seem.

With the exception of Dr. Joseph Ransohoff's paper (1913) all of the work has been done previous to 1870-1877 and each author has been able to report one or more personal cases. One would naturally conclude, if the subject of fatty hernias had been so thoroughly worked out during a period when, compared with the present, there was very little surgery done, that certainly the modern surgeons have overlooked the subject as evidenced by the paucity of the literature since 1877. It seems rather strange that the attention of the various authors has been drawn to the subject by either encountering a case or being directed to it by a friend.

The author of this paper, after having operated one of these cases, was personally referred by Dr. Joseph Ransohoff, in the Cincinnati Hospital Library, to his excellent paper on fatty hernias; otherwise I may have never known that there was such a subject.

That wonderful surgeon, Ambroise Paré, who has done so much for surgery, was perhaps the first to describe a case of fatty hernia, and in the report we gain an insight into the cause of his greatness, because it shows his unquenchable thirst for knowledge and his ability to make others profit by his labor.

Every abdominal surgeon is well acquainted with the subperitoneal fatty layer. In some patients it is quite thick while in others it is absent in certain areas. A study of cross sections of the above region will give one a better idea of the subperitoneal fatty layer than pages describing it.

If from violence or some other cause the fibres of the fascia composing the linea alba become separated, the intra-abdominal pressure will force first, the underlying fatty layer through the defect and eventually perhaps a peritoneal sac may be drawn through with the fat. The fat may increase into a well defined tumor, which usually has an artery passing into it. Because of the artery it is thought that the rent in the fascia occurs at a point where the former passes through the fascial layer. However, the majority of these fatty hernias occur at the location of and usually, but not necessarily, with inguinal or femoral hernias.

FATTY HERNIAS

So few cases have been reported, that a classical text book description of the symptoms is out of the question. Therefore, I will make a brief extract of some of the cases that I have been able to find.

CASE I (AMBROSE PARÉ).—"It is a priest of St. Andrew, named Jean Moret, who on Sundays sang to the epistles in the church. He had a large complete intestinal hernia, which he showed me, demanding relief, because he felt severe pain in it, particularly while singing. Seeing his suffering I told him that truly he should put someone in his place. This he did, praying the curate to substitute someone else and bewailing his own weakness. When this was accorded him, he placed himself in my hands and I prescribed several remedies suitable to his sickness, also making him a bandage which he wore during the period of five or six years. One day, asking him how his trouble was, he replied that he did not know that he had any and that he was cured. That, I would not have believed had I not seen it. Therefore, took him to my lodging and saw his genital parts without any trace of a hernia, and I was greatly astounded how he could have been cured in view of his age. About six months after I thus saw him, he died of pleurisy, and being advised of his death, I went to the house of the curate where the said Moret had lived, and prayed that I be permitted to open the dead body, to the end that I might learn what buttress nature had placed in the canal through which the intestines had descended. I protest before God that I found all around the groove of the peritoneum a fatty substance of the size of a small egg and attached so firmly to its surroundings that I had great difficulty in detaching it without breaking or tearing the adjacent parts, and this was the way in which a cure had followed."

CASE II (Reported by THOMAS ANNANDALE. Read before the Medico-Chirurgical Society of Edinburgh, January 5, 1870).—Dr. Annandale's attention was first directed to the subject by Professor Turner, 1860, in the dissecting room. He had made careful notes and drawings of the dissection and loaned them to Annandale. I think it is advisable to give Annandale's full report of the first case because it gives practically all of the anatomical features of a typical femoral fatty hernia.

"Subject, female, eighty-six years old. A large fatty mass was found projecting through the left saphenous opening. It was one and three-fourths inches long and one inch broad at its widest part. It was situated on the pubic portion of the fascia lata, somewhat constricted at the spot where it projected through the saphenous opening, being closely embraced on its outer surface by the superior cornu of that aperture. When the fascia lata was removed and the crural sheath exposed, and the different compartments cut into, the internal or crural canal was found to contain a considerable quantity of fat, which was continuous with the fatty mass projecting through the saphenous opening. In its descent, the mass had projected before it that part of the femoral sheath which forms the wall of the canal. *This investment had a thin transparent shining appearance which might at first sight be mistaken for the sac of the hernia.* When this investing structure was cut through, the fatty contents were found to be distinctly lobular and vascular; the *vessels being continuous with the vessels of the abdominal wall.* A funnel-shaped peritoneal sac was situated in the middle of the fatty mass extending for about half an inch downward. The fat was evidently nothing more than a hypertrophy of the subperitoneal fat of the wall of the abdomen with which it was continuous, superiorly through the crural canal. The peritoneal sac was smooth and transparent. The sac was empty, and its upper narrow end communicated with the general cavity of the peritoneum. The fatty mass was slightly adherent to the exterior of the sac." He describes another fatty tumor size of an almond in same subject which consisted of subperitoneal fat. It had passed through the

split fibre of the conjoined tendon and had as coverings the transversalis fascia and spermatic fascia. It emerged from the external abdominal ring but contained no sac.

CASE III (ANNANDALE).—Female subject, dissected 1860, had projecting through the left saphenous opening a mass of fat the size of a small orange and was covered by the femoral sheath. Within the mass was a femoral sac containing adherent omentum. On right side was a fatty mass the size of an almond, within which was a small empty peritoneal sac. It had the same anatomical relations.

CASE IV (ANNANDALE).—"Female subject dissected July, 1860. A lump of fat the size of an olive was found in the left crural canal and continuous with subperitoneal fat and crural ring. Within the mass was found an empty cul-de-sac of thickened peritoneum which was closed at the femoral ring by a distinct cicatrix."

CASE V (ANNANDALE).—Female subject dissected July, 1861. A mass of fat one inch long protruded through the left saphenous opening and was derived from the subperitoneal fat, it contained an empty peritoneal sac.

CASE VI (ANNANDALE).—Dr. Annandale dissected a middle-aged male subject in March, 1864. On the right side, a fatty mass, the size of a pigeon's egg, and on the left a mass a little smaller were discovered; each had pierced the fibre of the conjoined tendon and had carried down a peritoneal sac that communicated with the general peritoneal cavity.

CASE VII (ANNANDALE).—A male subject dissected December, 1869, was shown to Dr. Annandale by Dr. Chiene. On the right side was a large oblique inguinal hernia which had filled the scrotum. In the position of a direct inguinal hernia, on the right side was a lobulated mass of fat that contained a peritoneal sac which was closed where it joined the parietal peritoneum as evidenced by a distinct cicatrix. There was a similar mass of lobulated fat in the right crural region which was continuous with subperitoneal fat, but contained no peritoneal sac. There was a crural rupture on left that had some fat connected with the sac.

CASE VIII.—SIR A. COOPER saw a case in which a "Steatomatous" tumor in a woman was located in the situation of a crural hernia. It appears that a crural hernia had been gradually obliterated by the growth of a fatty tumor of considerable size.

CASE IX.—FARDEAN (*Sédillot's Journal de Médecine*, vol. xxiii, 1812) saw a case in a man aged sixty-five, who had three fatty herniæ, as follows: One near the ensiform cartilage, one at the umbilicus, and the last one associated with the left spermatic cord.

Annandale states that "Morgagni, Pelletan and Cloquet observed cases of this kind, in some of which there was a small empty peritoneal sac."

CASE X.—MR. COOK (*Med. Chir. Transaction*, vol. vii) reported the case of a married woman twenty-seven years old who presented symptoms of obstruction from a small tumor in the left crural region. It was very tender and irreducible and existed nine months. Operation showed it to be a hard lobule of fat that contained an empty sac.

CASES XI AND XII (COCK).—He also refers to two other cases which had a small tender protrusion of the linea alba which probably originated from the subperitoneal fat.

Dr. ANNANDALE saw a case with Dr. Chiene, a woman who was suffering with a painful fatty protrusion situated at the outer edge of the rectus muscle, and was the size of a small mushroom. After some weeks it returned into the abdominal cavity.

CASE XIII (ANNANDALE).—Dr. Annandale in June, 1867, saw a Mr. F., aged sixty-five, who suffered with symptoms of strangulated hernia. Dr. Bum was the attending physician. The patient had a femoral hernia on each side. The one on the left had been irreducible for many years and was of thirty years' standing.

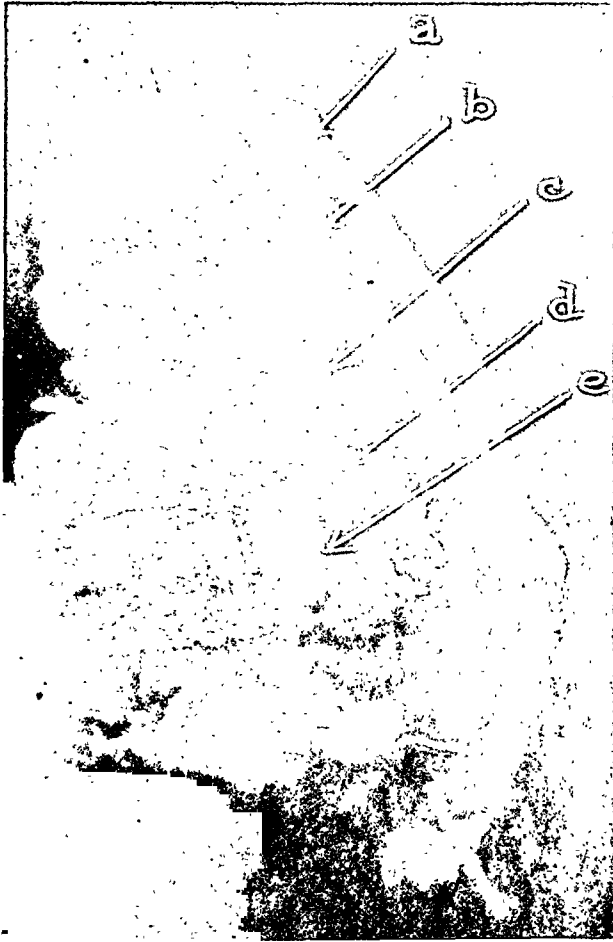


FIG. 1.—View of the umbilical region from inside. *a*, skin; *b*, superficial fascia; *c*, fat tumor external to superficial fascia; *d*, cut edge of linea alba; *e*, lobule of subperitoneal fat continuous with the tumor *c* through an aperture in the linea alba, *d*; no peritoneal sac.

FATTY HERNIAS

The other one was reducible. Vomiting of fecal matter led Annandale to operate the left side. A transparent shining membrane (the femoral sheath) was opened and contained a mass of lobulated fat the size of a pigeon egg which seemed to extend up into the abdominal cavity. Division of Gimbernat's ligament and an attempt to reduce the mass which was supposed to be omentum caused a distinct gurgle of a portion of gut returning into the abdomen. The mass was ligated for omentum and removed. Careful examination showed it to contain a sac. Good recovery.

CASE XIV (ANNANDALE).—Dr. Annandale was asked by Dr. Niven to see a woman aged seventy-eight years who was suffering from strangulated hernia for three days; it followed a sudden slip. She had had a small irreducible lump in right groin for several years. The tumor was the size of a walnut and was very tender and irreducible. At operation a lump of lobulated fat was found in what was at first thought to be a true sac. The mass had a true neck passing down from the abdominal cavity and was firmly grasped at the femoral ring. Annandale thought it was omentum and was on the point of returning it after cutting Gimbernat's ligament when he remembered his former case. A sac was found in the centre of the mass which contained a congested gut. The latter could not be reduced on account of stricture at the neck of the sac. When it was cut, the bowel was easily reduced. Patient made a good recovery.

CASE XV (Dr. FIFIELD's Fatty Hernia, *Boston Medical and Surgical Journal*, vol. 97, 1877. Attention was first called to this subject by the writings of Cruveilhier and M. Bernutz).—Dr. Fifield reports the following case: The patient, a man, had been forcibly ejected from a house during a fight, and had been jumped upon and pounded. A tumor was noticed near to and above the umbilicus. It had been considered a ventral rupture strangulated. Dr. Fifield, however, on seeing it, at once recognized a "fatty hernia" and cutting down on the tumor showed that the diagnosis was correct.

CASE XVI.—F. J. LUTZ, M.D. (in the *St. Louis Medical Journal*, vol. lvi, February, 1889) reported a case of "Fatty Tumor Complicating Femoral Hernia." Operation showed a pedunculated fatty tumor attached to the inside of femoral sac. It was three inches in circumference and microscopic examination showed it to be composed of fat.

December 10, 1912, Dr. Joseph Ransohoff read before Southern Surgical and Gynecological Association, Old Point Comfort, Va., a most valuable paper on "Fat Hernia," published in *Lancet Clinic*, January 4, 1913. Seven cases in all were reported from his long and extensive surgical practice, "and curiously enough only two of these were of the femoral type."

CASE XVII (RANSOHOFF).—Mrs. N., aged forty-three, entered Jewish Hospital December, 1894. Had irreducible hernia on right side of two weeks' standing. Patient was very slender. There is an ovoid tumor, lobulated and the size of a small hen's egg. It can be traced to the femoral ring. Impulse on coughing. Operation showed mass to be a subperitoneal lipoma that had passed through the crural canal. It had a well-marked pedicle fairly vascular but no peritoneal protrusion. Three years after, following sudden strain, patient developed a similar tumor of left femoral canal, no peritoneal sac.

CASE XVIII (RANSOHOFF).—Miss J. G., aged twenty-one, entered Good Samaritan Hospital, January 16, 1906, for right femoral hernia supposed. Six months before, patient had tumor in same region that could not be reduced, fever and obstructive symptoms followed. Operation performed to relieve the same. What was done then could not be determined. Two months following operation, tumor appeared suddenly and increased gradually in size.

Present Condition.—Beneath a recent scar in right groin is a tumor the size of a small peach which can be in a large measure reduced. Impulse on coughing. Operation showed a fat hernia that possessed a central funnel-shaped sac which would only admit a probe. The author follows with an opinion as to how the second condition was brought about.

"It is curious that the onset of these hernias is often unnoticed until an accident attracts attention to them. The following case is an illustration."

CASE XIX (RANSOHOFF).—O. J. F., aged twenty-eight, dining-car man, fell violently in a train accident. Pain was experienced in both groins. Three days after examination showed what seemed to be an indirect inguinal hernia on each side. Had a well-developed adipose layer. Tumors were size of a small peach and seemed partly reducible. Would recur without effort on the part of the patient. Impulse on coughing.

Operation under gas-oxygen anæsthesia, September 30, 1912, revealed a lobulated and encapsulated mass of fat on right and left side the size of a small peach, on the inner side of the cord and extending under the aponeurosis of the external oblique, terminating in a small pedicle. There was a small tongue-like sac extending through the centre of the mass. A small probe could barely be passed through it into the peritoneal cavity.

CASE XX (RANSOHOFF).—Mrs. L. B., aged twenty-seven, married five years, never pregnant. Two months before admission to Jewish Hospital, noticed a slowly developing, painless tumor in the left groin.

Physical Examination.—"The patient is a slender woman and presents nothing abnormal except the local condition. Occupying the right inguinal canal and extending slightly into the labium majus is a pyriform solid tumor the size of a small pear. To the touch it is lobulated and gives the impression of an omentocele. There is an indistinct impulse on coughing, and the tumor can be partly pushed back into the enlarged canal. The operation at the Jewish Hospital, February 8, 1907, for a supposed irreducible inguinal hernia revealed a nicely encapsulated subperitoneal lipoma on the outer side of the round ligament. Through its centre there ran a process not larger than a broom straw.

CASE XXI (RANSOHOFF).—Father H., aged sixty-four, February 10, 1909. Patient has had a right inguinal hernia for three years. It has been slow of development and painless, except when truss was worn.

Physical Examination.—Patient has a distinct tendency to obesity. In right inguinal canal and upper part of scrotum is a firm, rather smooth mass, as large as a peach and presenting a distinct impulse on coughing. The patient can apparently reduce the mass, but it can then be felt by the top of the examining finger.

"Operation, February 11, 1909, reveals a perfectly encapsulated subperitoneal fat tumor on the outer side of the cord. It is easily shelled out, but at its base there are running into it some quite large vessels. In the bed of the tumor there is exposed a circular area of the reverse side of the peritoneum, one inch in diameter, without any protrusion whatsoever, and moving distinctly with respiration. The operation was completed as an ordinary hernia."

CASE XXII (RANSOHOFF).—Miss F. P., aged thirteen, referred by Dr. Forchheimer. Patient felt a sharp pain in right groin and on examination the next day a tumor the size of a pigeon's egg was discovered. She was certain that it came on suddenly.

Present Condition.—Patient is very slender. "Projecting from the right inguinal canal is a tumor, like a pigeon's egg in size and shape. It is slightly movable, quite tender to the touch and irreducible. There is no impulse on coughing. Believing it to be a hernia, an immediate operation was performed at the patient's home, June 6, 1907.

"The operation revealed an encapsulated fat hernia with many fibrous strands

running through it. The vessels on the mass were greatly injected, and at its upper end there was a marked constriction, which accounted for the condition and the onset of the acute symptoms. No trace of a peritoneal protrusion could be found."

CASE XXIII (RANSOHOFF).—C. R., aged forty-nine, admitted to the Jewish Hospital, April 15, 1910. For many years he had had a right inguinal hernia for which he has worn a truss. For the last two years, however, he has not worn a truss, because of the pain which it caused and because the hernia did not seem to get any larger. The patient is a very fleshy man with an irreducible right inguinal scrotal hernia. It is the size of a good-sized peach with distinct impulse on coughing. The operation revealed an indirect inguinal hernia. Nothing unusual presented until the sac was opened, when there was found within it a lipoma as large as a small peach and attached by a broad base. The sac itself was like the finger of a glove and readily tied off. The operation was completed by the Bassini method.

Ransohoff describes a case of fatty epigastric hernia, the size of a plum. Case entered the Cincinnati Hospital service of Dr. Kramer. Patient was found delirious at home. Six months previous he had been in the hospital for acute nephritis. At operation the tumor was strangulated by a sharp ring formed by the margin of the recti muscles. No contents. Patient died in four days of chronic Bright's disease.

Ransohoff makes mention of a case reported by Wendel (*Zeisch. f. Chir.*, vol. 65, p. 388) in which fat tumor of the femoral region was strangulated by torsion. A fine process of peritoneum was found within the tumor.

CASE XXIV.—The following case is offered by the author, first because it represents a rare complication of an apparently rare condition; second, the anatomical relation being classical in this case, caused the author to be puzzled like a few of the previous writers.

My assistant, Dr. Elizabeth Shrieves, was called to see Mrs. L., aged seventy, widow, on Saturday, November 17, 1917, at one-thirty P.M., and from the patient obtained the following history: On Friday, November 16, 1917, the patient, late in the afternoon, helped her daughter lift a tub of dirt. She experienced a sudden pain in the region of right groin. After this she hoed in the garden for a short time but had to give it up on account of the pain.

She grew worse and Saturday, after dinner, Doctor Shrieves found her confined to her bed and complaining of extreme pain in right groin. Patient was vomiting and continued to vomit the rest of the afternoon. The doctor forgot to record the pulse and temperature. On examination a very hard, tender tumor the size of a small hen's egg was situated in the region of a femoral hernia on the right side. The doctor's recollection was that there was no impulse on coughing. She did not employ taxis but instead used hot and cold applications with the patient's hips elevated. She made three trips that afternoon to see the patient, and at eight P.M., when I was called to operate, the tumor had not been reduced. I did not take time to examine the patient because of her critical condition. The patient's previous history is of interest. She came to America from Cork, Ireland, when she was aged twelve. At the time of her immigration, she was carrying from two to four gallons of milk on her head daily over a milk route four miles long.

The patient has always been constipated; never had any serious illness. Has had frequent pain starting in right axillary line at costal margin and radiating down to the inguinal region on the same side. She never noticed a lump before in her groin. She has experienced the radiating pains for forty years or more.

Patient is slender, very frail, and possesses very little subcutaneous fat.

Operation at home; under ether anæsthesia. I palpated a solid tumor in right crural region; it was very prominent. A vertical incision was made over the tumor dividing the skin and subcutaneous tissue. This revealed a tar-black mass projecting through saphenous opening and situated within a thin transparent sac which was supposed to be the peritoneal sac of a femoral hernia. We had just come from the hospital where I operated on a lady of the same age for a strangulated femoral hernia on the right side. The femoral sac in this patient contained a gangrenous bowel, which we resected, which on inspection presented an identical appearance to the above case. I said to Doctor Shrieves, "Here is another bowel to resect," but on opening the thin sac I discovered that the mass was not bowel, omentum, bladder or any abdominal organ that I had ever seen. It was lobulated and had a shiny surface though black, and was apparently attached to the margins of the femoral ring where it formed a narrow neck. Like Annandale, I was puzzled, even more than he because I at once recognized that I was not dealing with any part of an intra-abdominal organ, but still there was a strangulated mass the size of a hen's egg apparently situated in a peritoneal sac that I must recognize and that quickly. I decided to *divide Gimbernat's ligament*. This I did by introducing the index finger of the left hand into the femoral ring the best I could and dividing the ligament with a pair of straight Mayo dissecting scissors. This solved the mystery, for, when I withdrew my finger, out slipped the vermiform appendix through the opening I had made in the true peritoneal sac at the femoral ring. The strangulated mass was a fatty tumor surrounding the peritoneal sac. The appendix was easily removed and showed no evidence of acute inflammation, therefore I do not believe that it was in the femoral sac at this time although, no doubt, it had frequently occupied this position. Microscopic examination of the appendix showed that the lumen was obliterated. The radiating pain of long standing might have been caused by irritation or pulling of the appendix while it was in the femoral sac. The thin transparent femoral sheath is the thing that has fooled us all. In my case it seemed to be identical with the femoral sac. The tumor was ligated and removed and the operation completed in the usual way. The patient made a good recovery, union was by first intention and she is enjoying good health, 1919. The radiating pain complained of for so many years stopped after the operation, and her constipation has been relieved.

CASE XXV.—While preparing this paper, I operated upon a case of fatty hernia of the umbilical region that I had seen in consultation

FATTY HERNIAS

with Dr. G. W. Wire on Thanksgiving day, 1918. At that time I made a diagnosis of umbilical hernia that contained an adherent piece of omentum. When the patient came in for operation, I reëxamined her and found just above the umbilicus a tumor mass about 2 cm. in diameter. There was no impulse on coughing, although the umbilicus itself was pouched out, the mass was not painful or tender and had been discovered by Doctor Wire while making a general physical examination of the patient. She is the mother of eight children, rather frail, there is small amount of adipose tissue, aged forty-two. A transverse incision surrounding the umbilicus was made and that region removed. There was no peritoneal pouch and the mass consisted of a lobule of fat that had passed through the linea alba just above the umbilicus (see Fig. 1). A small portion of the lobule could be distinguished from the internal surface of the linea alba. The operation was completed by Mayo's technic. Patient made a good recovery.

The differential diagnosis of Carsten Holthouse, the English authority, as quoted by Fifield, will be of interest at this point to show that we must change our views as new facts are added to the subject at hand.

- (1) They are of slow growth and come on without obvious cause.
- (2) Their growth and increase of bulk are progressive, never larger at one time and smaller at another.
- (3) When pinched up between the fingers, they are of lobulated, dimpled appearance.
- (4) When lifted off the parts below there is no impulse on coughing.
- (5) They are never reducible.

After a careful study of the foregoing cases, the following summary is offered.

1. Can be located in region of indirect inguinal hernia, in femoral region, linea alba or linea semilunaris.
2. They are gradual in development but onset of symptoms may follow a sudden exertion or injury and the patient first notices the tumor at that time.
3. May or may not have a peritoneal sac. The latter is usually small and empty but can have contents of ordinary hernias.
4. Fatty tumor can be on either the inside or outside of the sac if the latter is present.
5. Can become strangulated with an empty sac or even without a sac, and with or without torsion.
6. An impulse on coughing has been observed, but is generally absent.
7. False reduction in some cases is possible.
8. Diagnosis seems to be difficult.
9. Treat the same as an ordinary hernia.

ANURIA AFTER UNILATERAL NEPHRECTOMY*

BY LOUIS FRANK, M.D.

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At the 1914 meeting of the Southern Surgical and Gynæcological Society at Asheville, N. C., I reported five cases of anuria due to unilateral calculous obstruction, and discussed the subject from several viewpoints. In this paper I desire to record an additional case of anuria with an entirely different causative factor and which terminated fatally.

Miss E. T. came under observation in 1912, and again in June, 1915. The family history was negative for carcinoma, tumor, tuberculosis, insanity, etc. Father and mother living and in good health, as are two brothers.

Previous History.—At five years of age she had tuberculosis of the right hip, which, treated by Dr. V. P. Gibney, of New York, resulted in ankylosis of the hip and shortening of the right leg. At the age of seventeen a psoas abscess developed, from which she made a recovery. Later labial abscesses were present. Menstruation was always very painful, and for this the cervix had been dilated and a curettement done. Since childhood the patient has had pain over the appendiceal region, and at one time was sent to the hospital for operation, which, however, was not done. This pain has since been attributed to hypertrophy of the abdominal muscles.

For the past two years she has complained of extreme nervousness and has had attacks of hysteria. There have been numerous attacks of urinary retention requiring catheterization, large amounts of urine, however, being always found in the bladder. The bladder has been irrigated upon numerous occasions during the past two years, and, following cystoscopic and radiographic examination, the right kidney pelvis was repeatedly washed with collargol solution. The appetite has been poor, and she has in two years lost forty-six pounds.

Physical Examination.—Heart, lungs, liver and stomach normal. Abdomen soft; no masses felt, nor is there tenderness anywhere. Right hip ankylosed, the right leg much atrophied and three inches shorter than the left. Temperature 99.3° F., pulse 100, respirations, 20.

Urinalysis: Amber color, specific gravity 1004; acid reaction, albumin positive. There is a large amount of pus, no leucocytes, red blood-cells nor casts; few squamous epithelia.

Radiographic Examination.—Lungs and heart normal. Right kidney displaced downward; no renal calculi or other shadows. Pyelographic; right kidney displaced, low-lying, pelvis opposite fourth lumbar vertebra. Ureter normal in shape and position. Left kidney normal in position; ureter normal in shape and position.

* Prepared for the Southern Surgical Association Meeting, Baltimore, December, 1918.

ANURIA AFTER UNILATERAL NEPHRECTOMY

Cystoscopic Examination.—Bladder wall normal except in trigonal area. Here and at neck the vessels are enlarged and tortuous; trigone much reddened. Right ureteral orifice slightly distorted, swollen, some small punctate hemorrhages about it. Left orifice normal.

Indigo-carminc intramuscularly excreted from both kidneys about the same time, *i.e.*, about eight minutes. Phenolsulphonephthalein test—first hour 35 per cent., second hour 18 per cent. Left kidney urine, occasional pus cell only; right kidney urine, large amount of pus. No tubercle bacilli found microscopically in urine from either kidney nor in combined urines as obtained from the bladder which contains numerous organisms.

Guinea-pig inoculation: At the end of three weeks animal inoculated with centrifugalized urine from right kidney is much emaciated and autopsy shows gross lesions of tuberculosis involving spleen, liver and lymph-nodes in omentum in region of stomach. Smears made from these lesions showed a beaded acid-fast organism. Control pigs and one inoculated with urine from left kidney show no lesions suspicious even of tuberculosis. Diagnosis: Right renal tuberculosis.

Operation (July 1, 1915).—Nephrectomy, right kidney, under nitrous oxide gas-oxygen anæsthesia. Examination of kidney removed reveals "in the substance of the kidney a few miliary translucent nodules. There is present also a rather large caseous mass about 1 cm. in diameter near the pelvis. The ureter is distinctly thickened and involving the pelvis the lesion is uniformly distributed. Microscopically numerous typical miliary tubercles with giant-cell formation and epithelioid cells. There is also marked round-cell infiltration. Microscopical diagnosis: Tuberculosis of kidney" (Baldauf).

The patient's temperature night before operation was 100° F.; pulse 102; morning before, 99.2° F.; pulse, 108. She was returned from the operating room at 10 A. M. and given morphia sulphate $\frac{1}{8}$ grain. At my evening visit at 6 P. M. temperature 100° F., pulse 118; and the chart showed only two ounces of urine containing blood. She was immediately catheterized and four ounces of clear urine obtained. Saline proctoclysis was ordered. Twenty-four hours after the operation there had been no further excretion of urine, though twelve hours later one ounce of bloody urine was obtained.

Kidney decapsulation was advised but refused. The usual remedies were given, the loin cupped, etc. A catheter was introduced into the left kidney pelvis and warm saline lavage instituted. This resulted in the secretion of a few ounces of bloody urine, but with this one exception no further urinary secretion occurred until the nineteenth day, when one and a half ounces were voided. On July 20th several drachms were obtained by catheter.

Refusing repeatedly and constantly any further operative measures, with a full knowledge of the otherwise certain termination, the patient lived for twenty-six days, dying quietly without pain, conscious to within a very short time of her demise.

In reviewing the bedside history of this case there are several interesting points to which I would briefly like to call attention. This patient had been

having elevation of temperature for certainly a considerable period before entering the hospital, which elevation was maintained post-operative for three days. The temperature on admission and for several days before the operation was 101° F. The day following the operation the morning temperature was 99.2° F., evening temperature 100.2° F. On the second day the highest temperature was at noon, 99.4° F. On the third day the temperature receded to normal and remained so throughout the entire course until just before death of the patient, when it registered 102° F. axillary. The previous day the temperature had been normal. A small drain had been placed in one angle of the incision; this was removed on the fourth day, the wound healing primarily; and at the time of the patient's death no dressings had been worn for several days.

A study of the pulse and respirations might also be of some interest. The pulse following the operation was 110, rising to 120 that evening and remaining about the same for twelve hours. On the second day the pulse receded to 104; the third day it was from 76 to 88, and remained about the same until the sixth day, when it varied from 80 to 100. This range was maintained with some slight variations until six days before the patient's death, at which time it began to gradually rise, the highest point reached at any time being 130, but never under 100. The volume, which was good at first, became very much less a few days before death.

The blood-pressure was 112 mm. Hg at the time of operation. On the fifth day it was 100, the seventh day 105, the ninth day 119. It did not vary markedly from this, the reading ranging from 116 to 120 until within the last few hours, when it gradually became lower.

The most marked effect of cessation of the urinary secretion seemed to be upon the respirations, which were reduced within forty-eight hours to 16, then to 14, remaining 12-14-16, both waking and sleeping, until the nineteenth day, when they were read as 8; on the twentieth day as 6; varying between 6 and 8 during the remainder of the patient's life until twenty-four hours before death, when they reached 18, remaining between this and 24-26 to the end.

A study of the blood urea was impossible on account of the opposition of the patient and her family to making repeated records. However, seven days after the operation there were eighteen parts of urea in ten thousand, an estimate of 83 milligrammes of urea in 100 c.c. of blood. Twelve days later this had risen to 172 milligrammes of urea nitrogen per 100 c.c.; and about four days later this was increased to 200 c.c. No further blood was had for the reasons stated. It would have been interesting to have kept an accurate record of this condition.

The bedside chart reads that there was no nausea immediately following the operation, but the patient began vomiting eight hours after she was placed in bed, and without any cessation this vomiting was continued four or five times daily until her exit. The vomitus consisted of bile-stained fluid at first; later it began to contain some undigested food particles; and

ANURIA AFTER UNILATERAL NEPHRECTOMY

the day before death it became brown in color, contained blood, and had a very offensive odor.

Alvine evacuations occurred every day, and were at times very thin and offensive, probably due in part to the administration of purgatives in an effort to maintain elimination through the intestinal tract. For several days, from about the fifteenth until the twentieth day after the operation, considerable blood was passed by the rectum and a great deal of mucus. During this time no purgatives were given. The patient was able to take nourishment constantly, there was never the slightest mental disturbance, her mind being perfectly clear until within twenty-four hours of death. She slept well every night, had her daily bath; there was no twitching, no headache, no visual disturbance; in fact, she seemed normal in every way so far as her appearance was concerned from ordinary physical observation.

On the twenty-second and twenty-third days she hiccupped quite frequently during her waking hours. She was out of bed daily for variable periods of time, being up in a roller chair and at times walking about the room from the twelfth day until twenty-four hours before her death. The patient, of course, necessarily was much perturbed on account of her inability to pass urine, and would become very much excited and nervous and at times would talk of it constantly, so that it was difficult to get her to sleep. Because of this she was given occasional doses of morphine or veronal at bedtime. There were never any convulsions or any evidence other than that found by blood examination of urea retention.

In reporting this case in such detail we do so with the idea of eliciting some discussion, particularly as to the cause of this occasional sequel of nephrectomy. Numerous cases have been reported in the literature where suppression varied from a day or two to as much as eight or ten days; and if I mistake not Morris cites a case of thirty days' duration.

It might be that this case should not be classed as one of complete anuria, as a little urine was voided upon several occasions during the patient's illness. The tolerant stage, however, in this case resembles in its duration that which we have with calculous anuria, though some of the symptoms which we have observed in calculous anuria were not present in this individual.

We are still of the opinion that not only in calculous anuria, but in the occasional suppression which follows nephrectomy, the suppression is brought about entirely through circulatory disturbances. We think that the term reflex anuria indicative of some nerve connection or nervous reflex is a misnomer. Our studies some years ago in ureter ligation showed a compensatory vascular activity in the kidney with the open ureter. In every instance the afferent vessels became overfilled with blood. The efferents can only contain a certain amount of blood, and we have happening here just exactly what happens in a *stampede* of a crowd at a theatre fire. A few get out, but the large mass (the blood on the afferent side) is held back.

We believe it is this active arterial congestion, this vascular overfilling, particularly on the arterial side, which accounts for the diminution in the urinary output in practically all cases of unilateral nephrectomy during the first few hours. As soon as the circulation on both sides in the kidney is equalized, then we have an increase in the urinary output and the kidney gradually accommodates itself to performing the function of both organs.

We would again offer circulatory disturbances as the explanation of anuria not only in this case but in those due to unilateral calculous obstruction.

ADHESIVE PLASTER METHOD FOR THE RAPID REGENERATION OF SKIN OVER GRANULATING WOUNDS

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THE simplicity of this procedure and its effectiveness prompt me to publish it. It has, moreover, an extensive application. It may be applied in all types of granulating wounds, whether these be due to ulceration, burns, or trauma, and especially wounds produced by surgical operations. Perhaps the most important field for this method is found in the demand for skin regeneration over denuded surfaces produced in the skin sliding operation. This method is now widely employed in the treatment of the apparently hopeless cases of chronic suppuration of bones and joints, empyema, and lung abscess. It is mainly for such cases that the method here is described.

Method of Application.—The technic consists in applying strips of plain or zinc oxide adhesive plaster along the edges of the granulating wound. These strips, one-half to three-quarters of an inch in width, must be so adjusted that they cover both margins, that of the skin and that of the granulating wound. This leaves the centre of the granulating surface exposed for absorption of the wound secretions by a dry sterile dressing.

Twenty-four hours later the dressing and adhesive plaster are carefully removed. It will be found that along the margin of the skin there has now formed a bluish-gray border, about 2 or 3 mm. in width. This bluish-gray border represents the new growth of epithelial cells.

The wound is now dressed with dry gauze, which is left on for twenty-four hours, followed on the next day by another application of adhesive plaster. This procedure is repeated until the entire granulating surface is covered with an epithelial growth.

All necrotic tissue must be allowed to slough off, so that the base of the wound is clean, before we can expect the epithelium to grow. The wound must never be rubbed with gauze, as this would be apt to destroy the new epithelial cells.

A mistake which is frequently made is to draw the surfaces together with the adhesive strips. This is not the intention. On the contrary, the wound edges should be kept apart as much as possible, so that the skin may grow along a flat surface. When the skin grows into very deep recesses, so that the skin surfaces are in contact, we are likely to produce a pocket in which the skin secretions would accumulate and undergo decomposition, thus causing a bad odor. To prevent this, we must plan our operations so as to produce a funnel-shaped depression which can be properly ventilated.

The adhesive plaster method of treatment suggested itself to me when, in 1910, I watched its effects in treating extensive burns by one of our assistants, Dr. S. Kositchek. He applied the adhesive plaster on electric burns of second and third degree (caused through setting fire to the clothes) which often extended over the entire chest or back, and with proper application of this method, these surfaces gradually became covered with what appeared to be a dry, normal skin.

Adhesive plaster was already used twenty years ago in the treatment of chronic ulcers, as is stated by Doctor Jackson, of Kansas City, in his discussion of my paper in 1916, when I brought this matter up in Omaha in connection with the treatment of chronic osteomyelitis by the skin sliding operation. He stated that this method of treatment may have a much wider application but that Dr. Carter Cole, of New York, had already used it twenty years before.

Many substances have been used to stimulate skin regeneration, such as balsam, acacia and paraffin and scarlet red. None, however, fulfilled the requirements as has the adhesive plaster. Its action is largely mechanical, as explained in an article written by Dr. Charles A. Parker in the *Journal of the American Medical Association*.

Explanation of the Rapid Epithelial Growth.—The reason why large granulating surfaces have no tendency to be covered by epithelium until skin grafts are used, is this: The granulation tissue grows much faster than the epithelial growth and thus we find that the granulating mass overlaps at the margin of the wound. In other words, the granulating mass is much higher than the skin level. The epithelial growth stops at this margin because it cannot grow upwards over the elevated granulating surface.

In order to overcome this obstacle we must establish a level surface, merging from the skin over the granulating surface, and this is accomplished by pasting adhesive plaster over the margin. It keeps the granulations from rising any higher than the skin and this gives the epithelium a chance to regenerate underneath the surface of the adhesive plaster. The epithelial cells will grow rapidly under these favorable conditions and cover as much as one-quarter inch in twenty-four hours all around the wound, which is plainly visible by the appearance of a bluish-gray border. The under surface of the adhesive plaster acts as a path for the regeneration of the cells, on the same principle as the vine would grow along a string or wire and cover within a short period the entire wall of a building. If the strings were not there the vine would grow in all directions. It is the string that keeps it close to the wall, and so with the adhesive, the adhesive furnishes a trellis for the growth of the epithelial cells.

This explanation of the growth is not entirely theoretical, it is based upon experimental study on animals and more extensively on the human. The microscopic examination of specimens cut out for this purpose from

ADHESIVE PLASTER DRESSING OF WOUNDS

healing wounds has proven this beyond doubt, and I desire to present some of these microscopic sections.

For illustration I exhibit a schematic drawing, Fig. 1, which is self-explanatory.

I have employed the adhesive plaster method in over 100 cases, with the most surprisingly beneficial results. For illustration, I wish to cite but a few cases, the illustrations of which will speak for themselves.

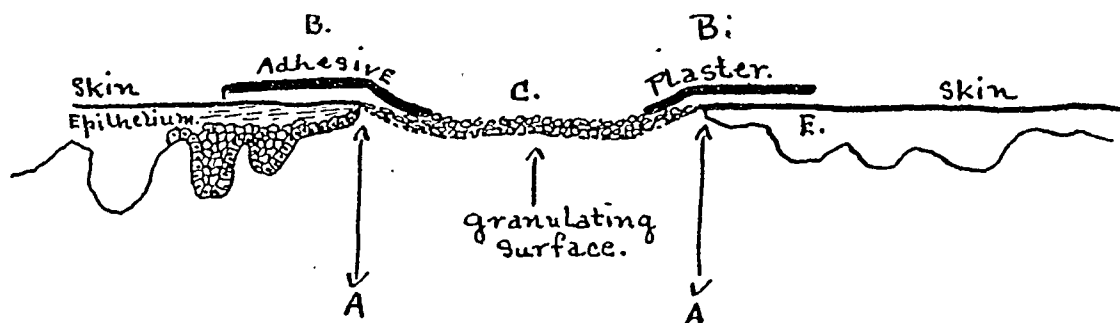


FIG. 1.—AA, margin of epithelium bordering on granulating surface. BB, adhesive plaster covering both margins, skin and granulations. C, exposed granulating surface.

CASE I.—Microscopic Section of Skin Removed from a Lung Abscess, Three Years after Operation.—A young man, twenty-four years old, with an abscess in his lung for nearly six years, due to the inhalation of a pin-tack, was operated on by me in 1908. The pin-tack was removed but the abscess would not heal, since it had seven small openings communicating with bronchi.

I decided to make a skin sliding operation in 1914, to expose all these bronchi and cauterize them with the actual cautery for the purpose of obliterating them. I was, however, unable to obliterate all seven bronchial openings because three of them were so located that I could not introduce the cautery into the openings.

I, therefore, decided to resect more ribs, to make these bronchi accessible to treatment. In doing so I was obliged to resect some of the skin, Fig. 2, which had grown into the deep recesses of this lung abscess by means of the application of adhesive plaster.

From this newly formed skin I made microscopical sections, which showed distinctly the regeneration of the epithelium very nearly that of normal skin. There is a distinct basement membrane between the connective tissue of the outside and the epithelial layer, Fig. 3. There is no evidence of any glands, however, and in this respect this newly formed skin differs from the normal. But for practical purposes the skin surfaces so covered are usually dry and fulfill the requirements of normal skin for covering wound surfaces. At any rate, it is the best substitute for normal skin, for it has no tendency to contracture. In the older cases we can lift up this skin from its base, just as we can normal skin, which we cannot do with old scar tissue.

CASE II.—Osteomyelitis of Ribs and Destruction of Right Costal Arch.—J. K. age forty, male. Three years ago (1915) developed a swelling and pain in the right costal arch. The swelling was opened

and pus found. Did not heal, however; the wound kept on discharging for two years and then patient consulted me. Examination revealed three discharging sinuses in the right costal arch, one at the level of the mammary line, at about the eighth rib, the other two near the costal margin. Bismuth was injected through the upper opening but came out through the two openings lower down.

Operation on June 11, 1918, consisted in the resection of the entire right costal arch and two inches each of the eighth, ninth and tenth ribs. The skin overlying this area, which had degenerated from persistent discharging sinuses, was entirely cut away and an area six inches in diameter, as shown in Fig. 4, was left entirely denuded for granulation and for subsequent treatment with the adhesive plaster method.

Fig. 5 demonstrates the application of the adhesive plaster along the edges of the wound.

The regeneration of the skin from the edges took place rapidly and within two months the entire area was covered with skin. Fig. 6.

CASE III.—*Skin Sliding Operation for Empyema*.—Young man of twenty-six, who retained a fistulous empyema subsequent to a pleuro-pneumonia six years previous. The case had the usual history of resection of one rib and drained with no tendency to permanent closure.

A skin sliding operation was performed in June, 1917. Fig. 7 illustrates the skin flap in the wound, after the resection of the rib, and exposure of about 3 or 4 inches of granulating surface from which the implanted skin had been denuded. At this stage about one-half of the denuded surface is already covered with newly-formed skin; six weeks later the entire denuded area was covered with newly-formed skin, the funnel-like depression and the entire tract down into the pleura. The wound is perfectly dry and the skin is movable from its base. Fig. 8. For illustration of the adhesive plaster in empyema cases, I illustrate Fig. 9, which shows the strips of adhesive plaster dipping down along the edge of the resected ribs and covering the under surface of the costal pleura.

In the empyema cases the application of the adhesive plaster is a little more difficult, but with proper care it can be carried out with success.

CASE IV.—*Osteomyelitis of Femur with Skin Sliding*.—The case here illustrated represents a type of chronic suppuration of the femur not very uncommon. It has existed for about fifteen years. All previous operations and also the bismuth treatment had been found ineffective, because it was discovered that the shaft of the femur up to the middle was filled with sequestra and pus. The knee-joint was also affected.

The skin sliding operation was performed in 1917. Figs. 10, 11 and 12 illustrate the progress of regeneration of the skin over the denuded surfaces. In Fig. 10 we note that the greater part of the quadriceps muscle is exposed and also a great part of the gracilis muscle. The skin dips down into the depth of the excavated

ADHESIVE PLASTER DRESSING OF WOUNDS

femur. Fig. 11 illustrates the condition two weeks after the operation. Granulations have now formed over the entire surface and skin is beginning to form along the margins.

In Fig. 12 the entire surface is now covered with skin, no discharge present.

Patient, later on, had some operations below the knee, which were treated in the same way and with equally good result. He is now back at his work, a plumber.

CASE V.—*Osteomyelitis of Femur. Skin Sliding*.—Illustrates the procedure in a case of osteomyelitis of the femur near the hip. A skin flap is prepared during the incision, which is to dip down into the recess formed by the removal of the diseased bone in the femur. Without using any suture, the tip of the skin flap is tacked down temporarily into the bone, as shown in Fig. 13 and the entire surface is left exposed. In Fig. 14 we note the process of healing and in the picture we see the clear margin of the new growth of skin between the true skin and the granulating surface. In Fig. 15 the entire area is now covered with skin.

The photographs give the impression that the healed area is scar tissue. This is not the case, this photographic effect is due only to the difference in color of the skin, for this new-formed skin is movable and on microscopic section proves to be composed of epithelial structure.

CASE VI.—*Tuberculosis of Fascia Lata and Muscles*.—This represents the progress of an operation for tuberculosis of the fascia lata and underlying muscles.

A nurse, thirty years old, had previously had six operations for this condition without any result, the entire surface draining from many points of the old incisions and scars.

In Fig. 16 we see the condition right after the second operation, the dark part is the granulating surface after the operation performed previously, the part marked "B" had been denuded four days previously. Here we had an exposure of about a foot in length and about 8 inches in width and about 2 inches in depth.

The adhesive plaster method was used here and eight weeks later the epithelial growth progressed to the point illustrated in Fig. 17. A month later it was covered to the size illustrated in Fig. 18. There is no discharge and the nurse is back at her work.

CASE VII.—*Ulcer of Leg Unresponsive to Skin Graft, treated with Adhesive Plaster Strips*.—Illustrates an ulcer of the leg in a young man which had existed for some five years, with no tendency to healing, as shown in Fig. 19. We made several experiments in this case to cure this persistent ulcer. We cut away an area of about three inches in diameter, clear to the border of the true skin and then made a transplant of skin from the thigh, as shown in Fig. 20. This, however, sloughed out, as shown in Fig. 21. We now tried Thiersch grafts, but these also sloughed away. There seemed to be no tendency in the base of this ulcer for nourishing any skin graft or skin transplant. Thereupon, I tried the adhesive plaster method and suc-

ceeded in regenerating the skin completely within four weeks, as shown in Fig. 22, the patient being able to use his limb, the skin being perfectly movable over the regenerated surface.

CASE VIII.—*Redundancy of Skin Produced by Adhesive Plaster Method in Extensive Burn.*—S. G., a young boy of twelve. Was brought to me at the age of three years with a very extensive burn of his left chest, back and shoulder, as well as the left arm to the elbow, produced by setting his clothes afire. The burn was so extensive that it was advisable to allow the arm to grow on the chest wall, in order to diminish the area for granulation, as seen in Fig. 23.

Two weeks later we began to treat the granulating surface with adhesive plaster from the edges of the burn. Later on separated the arm from the chest wall, continuing the application of the adhesive plaster until the entire area was covered with new skin.

I exhibit photograph, Fig. 24, of the boy in his present condition, at the age of twelve. It shows the entire area covered with movable skin, which can be lifted from the underlying tissues and the arm can be extended in all directions. In fact, he plays the violin without any difficulty.

CONCLUSIONS

1. The adhesive plaster method for regeneration of the skin is the simplest and most effective, and in a great measure supplants the necessity of skin grafting.

2. It is applicable in all granulating wounds, whether they be produced by injury, by disease, or be subsequent to operation.

3. The epithelial covering thus produced is only in appearance somewhat different from normal skin but serves practically the same purpose as a skin transplant.

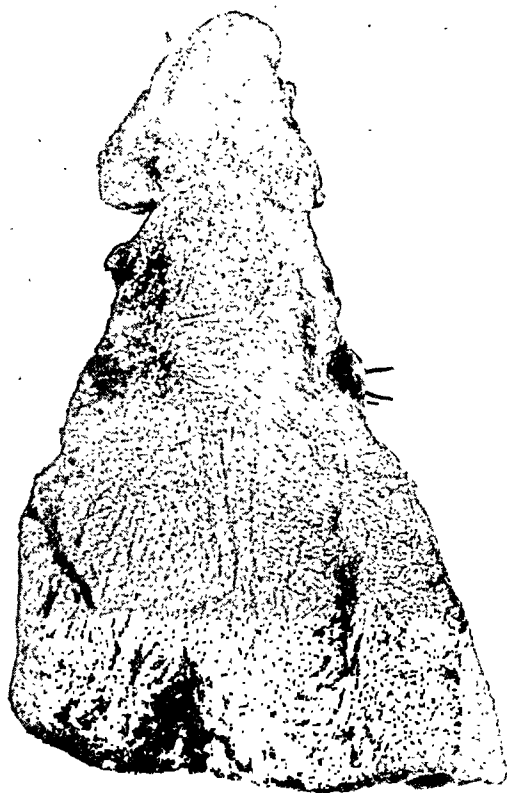


FIG. 2.—Triangular flap of skin removed from interior of lung abscess three years after operation.

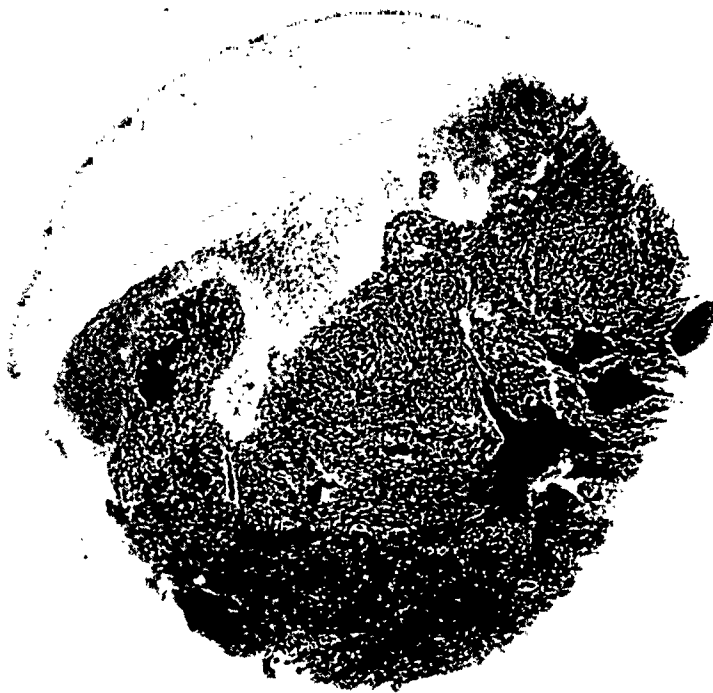


FIG. 3.—Case I. Microscopic section of newly formed skin, removed several months after formation.



FIG. 4.—Case II. Showing granulation surface remaining after resection of costal arch.



FIG. 5.—Case II. Showing method of application of the adhesive plaster.

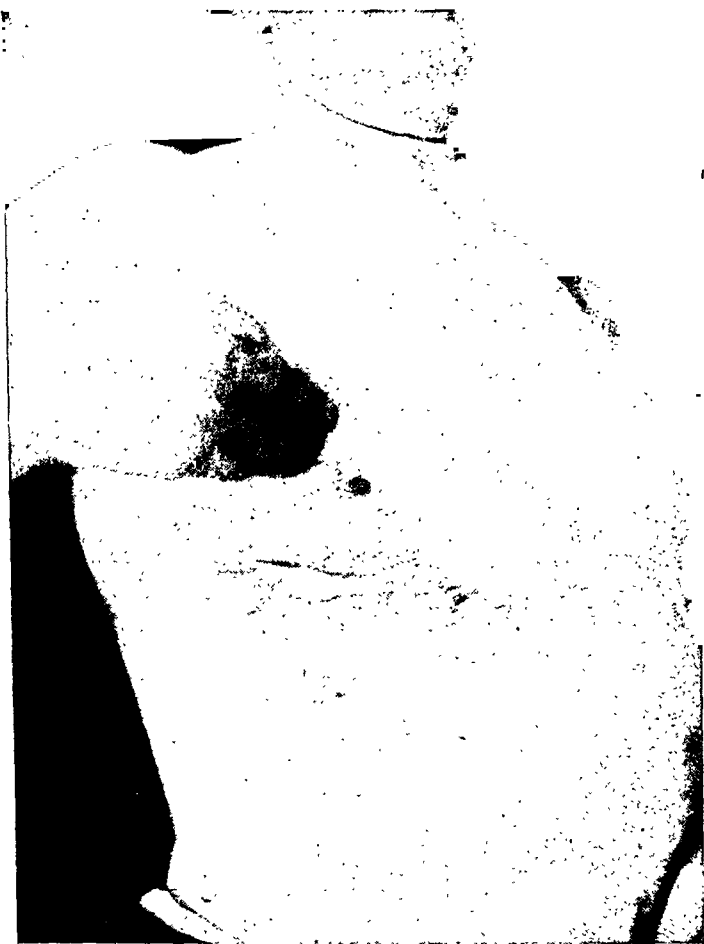


FIG. 6.—Case II. End result.



FIG. 7.—Case III. Condition of skin flap two weeks after operation. Granulating surface three inches in width, eight inches long.



FIG. 8.—Case III. Denuded surface now covered with new growth of skin. Funnel-shaped depression dry.



FIG. 9.—Illustrates the method of applying the adhesive plaster in cases of empyema where the skin sliding operation has been performed. Strips must run beyond the border of the growing skin.



FIG. 10.—Case IV. Condition three days after operation. Note large area exposed for granulation.

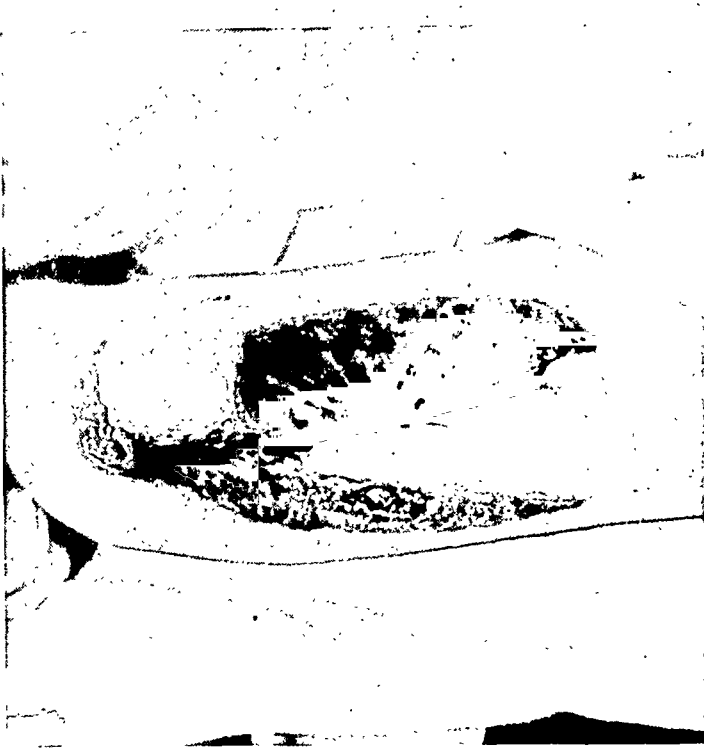


FIG. 11.—Case IV. Reduction in size of granulating surface by new growth of skin along edges. Two weeks after operation.



FIG. 12.—Case IV. Skin now covers all but the crevices in the two incisions. No discharge (six weeks later than Fig. 11).



FIG. 13.—Case V. Skin flap tacked into the canal of the femur. No sutures used. Large area left exposed for granulation.



FIG. 14.—Case V. Three weeks later than Fig. 13. Demonstrates clearly the new skin formation along edges.



FIG. 15.—Case V. Complete closure. Entirely covered with new growth of skin.



FIG. 16.—Case VI. Condition four days after second operation. Dark area is granulating surface from previous operation. *B*, surface two inches deep.



FIG. 17.—Case VI. Condition eight weeks later. Margin designated by *a*, new growth of skin.

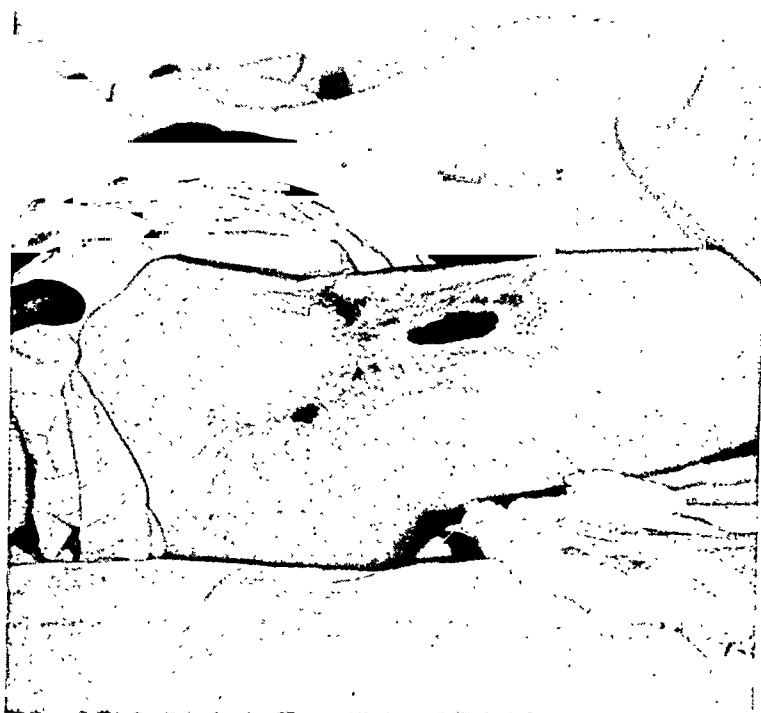


FIG. 18.—Case VI. Condition four weeks later. Only about two inches square granulating surface remaining for complete closure.

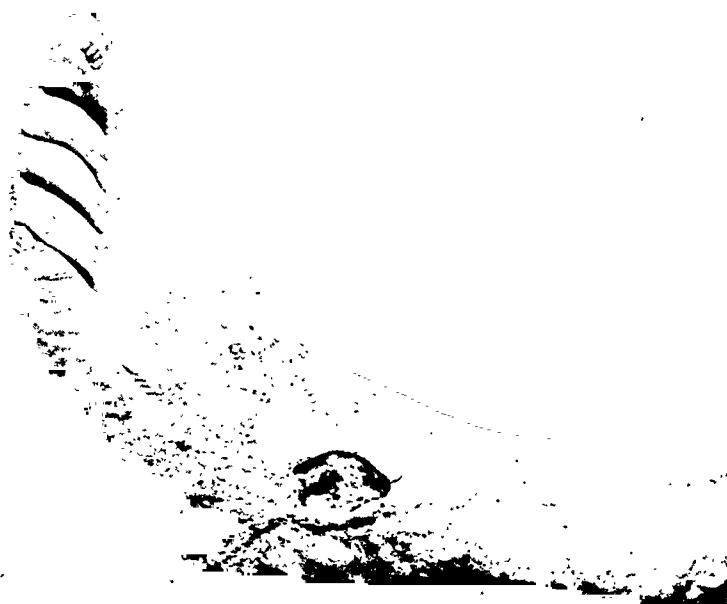


FIG. 19.—Case VII. Condition of chronic ulcer, five years standing, surrounded by unhealthy skin.



FIG. 20.—Case VII. Transplant of skin from thigh sutured to healthy borders.



FIG. 21.—Case VII. Transplant sloughed, leaving denuded surface with unhealthy granulations.



FIG. 22.—Case VII. Result of adhesive plaster method, new skin movable from base.



FIG. 23.—Case VIII. Extensive burn. Upper arm grown to chest, to temporarily diminish granulating surface.



FIG. 24.—Case_VIII. Nine years later. Showing mobility of newly formed skin from underlying tissues.

EXPERIMENTAL RESEARCH ON THE EFFECT OF INTRA- VENOUS INJECTION OF GUM SALT SOLUTIONS*

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SERIOUS effects have been reported at certain times to have followed intravenous injection of gum salt solution in cases of shock. While it is most probable that such results may have been principally due to improper selection of cases, it was thought possible that other factors than the condition of the recipients may have been involved. Among other possibilities, the chance of the occurrence of anaphylactiform disturbances was considered to be worthy of investigation. Gum acacia, a substance in the colloidal state, might interact with the blood colloids or the surfaces of body cells with the production of harmful results.

It is well known that kaolin, agar, Witte peptone, and certain other substances with the properties of surface produce anaphylactic-like phenomena when introduced into the circulations of animals. It was from this standpoint that this work was undertaken. Guinea pigs were chosen as the recipients for the injections, as these animals are known to be the most sensitive reagents for this type of reaction.

Source of Material.—With one exception, all the samples of gum tested were made at the central laboratory. The bottles containing the gum were in every case except one marked with the date of its preparation. All of the material tested had been put up and sterilized in 500 c.c. bottles fitted with clamped tops. All of the preparations contained the standard concentration of gum (6 per cent.) in 0.85 per cent. NaCl solution. The samples were obtained from three sources, *i.e.*, reserve stock, chemical laboratory, storeroom, central laboratory, and from the medical supply dumps at the front. The origin of the material used in the various experiments will be indicated.

It was found impossible to obtain accurate information in regard to the exact raw material used in the preparation of the different samples. In general, the raw material was from three sources, English powdered gum acacia, French powder and the unground "tears." But no record has been kept of the material used for definite samples.

Similar difficulties were met with in trying to ascertain the exact process of preparation of each solution. The degree of heating to bring into solution, the methods of clarification and filtration, and the length of time of sterilization were apparently changing experimental matters of which no clear record was kept. As the investigation has turned out this lack of concise detail was not a serious matter, but in case certain toxic samples had been met with such data would have been sadly missed.

* Submitted, January 7, 1919.

Toxicity Tests on Various Samples. Method of Calculating Dosage.—The preliminary experiment consisted in intravenous injection into guinea pigs of the latest preparation obtainable from the chemical laboratory. Approximately $1/6$ blood volume was used as the dose in this experiment. The blood volume of the animals under test was assumed to be approximately $1/13$ th of the body weight. Consequently the formula-body weight in gms. $/13$ was used in this and following experiments.

Speed of Injection.—The speed of injection used in these experiments was much greater than that employed in actual application of the gum to shock cases. This was done in order to throw a maximum strain on the resistance of the animal. It is well known that disturbances of the anaphylactic type may be avoided by extreme slowness of injection. Since it was the purpose in these experiments to find out whether under any condition gum could induce reactions of this type it was considered wise to inject at the maximum speed tolerated by the animal. The small and moderate sized doses were injected in 60 minutes, the larger ones, $1/2$ and $2/3$ body weight in 90 to 120 minutes.

Technic of Injection.—No attempt at replacement of blood volume was made. The plethora resulting from the injection of large quantities did very little damage, since out of over two hundred animals injected, only three suffered from rupture of some part of the circulation. The solutions were carefully warmed to 42 degrees before injection. Injections were made with Luer syringe into the left internal jugular vein. The guinea pigs were immobilized upon Latapie boards, the neck shaved, iodized and a small oblique incision made lateral to the median line. The vein was then easily exposed by blunt dissection. The injections were carefully timed. Oozing was prevented by the use of a small needle and the application of a pledget of cotton after withdrawal of the needle. The animals were at once removed from the board after injection and kept under observation for twenty-four hours. They were most minutely observed during the first hour after injection. Throughout the experiments precautions for sterility were rigidly observed. Sterile pipettes were always used in transferring the gum from the bottles to test tubes and flasks. In short, the experiments were conducted with rigid bacteriologic technic.

Number of Animals Used to Test a Given Dose.—In the course of investigations on anaphylaxis and related phenomena it was observed that there is marked irregularity of susceptibility in guinea pigs. These animals display a considerable variation of resistance to injections of substances in the colloidal state and to serum rendered toxic by admixture with such substances. Animals of a given weight cannot, therefore, be considered as uniform reagents. It is inadvisable, therefore, to draw conclusions from the effect of a single dose on one animal. Two, three, and even more guinea pigs had better be employed on the chance that a

INTRAVENOUS INJECTION OF GUM SALT SOLUTIONS

certain percentage of these will be far more susceptible than others. This plan was followed out in all of the experiments described below.

Test of Gum Salt Solution A-p 1.—This solution was prepared November 10th. In appearance the solution showed a pearly-gray opalescence. There was no precipitate, nor could any suspended particles be detected by the unaided eye. The technic used was that just described. The dose given was 1/6 blood volume.

TABLE 1

No.	G. S. sol.	Inj. time in sec.	Wt. g. p. in gms.	Dose in c.c.	Result
1	A p. 1	65	426	5.3	Hyp. excit. shivers.
2	A p. 1	59	495	6.3	Like 1.
3	A p. 1	78	547	7.0	Violent shivering.
4	A p. 1	59	377	4.8	Hyp. excit. urin.
5	A p. 1	70	462	6.3	Nil.

Very slight results followed the injections just summarized in Table I. Hyperexcitability, urination and defecation and shivering are frequently observed as precursors of violent shock of the anaphylactic type. Sometimes these are the sole effects observed when sub-fatal doses are given. On the other hand, such effects are vague, not capable of accurate measurement and in no sense quantitative indicators of a disturbance of this type. From such symptoms as those following the injections just described absolutely no conclusions can be drawn. In subsequent experiments they will be lumped under the designation, "very slight effect," and particular attention will be called to them only when one, such as peripheral irritation, is particularly marked.

In reactions occurring between substances in the colloidal state it is frequently observed that too great concentration of one or both of the reacting substances inhibits the process. Consequently it was thought wise to inject doses lower than 1/6 blood volume as well as those higher than that proportion. In other words, it might be possible to introduce into the circulation such a concentration of gum as to inhibit any reaction that would tend to take place.

Using the same sample of gum, therefore, as that employed in the first experiment, guinea pigs were injected with a wide range of doses, from 1/10 to 1/2 blood volume. Three animals were employed for each of the above doses in order to avoid the error of interpretation that might arise from one negative result.

The experiment was carried out with the same gum (A-p 1) as that used in Table I. The same methods of calculation of dose and the same general technic obtained throughout the experiment.

The results of this experiment will be found to be summarized in Table II.

A glance at the results recorded in Table II will indicate that very large amounts of gum salt solution may be introduced into the circulations of guinea pigs with no very harmful result. It is worthy of notice,

TABLE II

No.	G. S. sol.	Propor. bld. vol.	Inj. time in sec.	Wt. of g. p.	Dose in c.c.	Result
1	A p. 1	$\frac{1}{10}$	60	405	3.1	V. sl. effect.
2			60	420	3.2	V. sl. effect.
3			60	370	2.8	V. sl. effect.
4	A p. 1	$\frac{1}{8}$	60	400	3.4	Nil.
5			58	347	2.8	V. sl. effect.
6			60	450	3.6	V. sl. effect.
7	A p. 1	$\frac{1}{8}$	60	375	3.5	V. sl. effect.
8			60	450	4.3	Nil.
9			60	405	3.8	Nil.
10	A p. 1	$\frac{1}{4}$	60	355	3.8	P. i. marked.
11			60	365	4.0	P. i. extreme.
12			60	470	5.0	P. i. ex. degree.
13	A p. 1	$\frac{1}{4}$	58	475	7.2	Ex. lab. resp.
14			55	425	6.5	Sl. spasms.
15			55	345	5.3	V. sl. effect.
16	A p. 1	$\frac{1}{4}$	65	470	9.0	V. sl. effect.
17			58	454	8.7	V. sl. effect.
18			85	654	12.0	V. sl. effect.
19	A p. 1	$\frac{1}{3}$	65	400	10.0	V. sl. effect.
20			68	407	10.3	V. sl. effect.
21			60	423	10.6	V. sl. effect.
22	A p. 1	$\frac{1}{2}$	85	365	14.0	P. i. hyp. excit.
23			95	360	13.5	V. sl. effect.
24			100	360	13.5	V. sl. effect.

furthermore, that of all the doses given the $\frac{1}{7}$ blood volume produced the most noticeable effect. The peripheral irritation noticed in all three of the animals injected with this dose is a quite common preliminary to the disturbance of the anaphylactic type. The effects in the cases of Nos. 10, 11 and 12 were so striking that three more guinea pigs were injected with a similar dose. In two cases out of three some peripheral irritation was observed, although not to so marked a degree as in the case of the first three.

Test of Gum Solution B p. 1.—This solution was much older than that used in the experiments just described. The solution was prepared on September 7, 1918, approximately three months before the day of injection. Although the solution was of a pearly-gray opalescent appearance similar to that of A p. 1, there was a considerable precipitate in the bottom of the bottle. This, upon vigorously shaking the container, went into suspension and remained in this condition for several hours before settling out. Accordingly, the bottle was well shaken before the solution was transferred to test tubes. These tubes were placed in the water bath at 42 degrees for twenty minutes before the beginning of the injections.

In this experiment $\frac{1}{7}$, $\frac{1}{6}$, $\frac{1}{4}$ and $\frac{1}{3}$ blood volume was injected. Three pigs were injected with the first named proportion, two each with

INTRAVENOUS INJECTION OF GUM SALT SOLUTIONS

TABLE III

No.	G. S. sol.	Propor. bld. vol.	Inj. time in sec.	Wt. of g. p.	Dose in c.c.	Result
1	B p. I	$\frac{1}{4}$	60	350	3.8	V. sl.
2			60	430	4.7	Ur. p. i. spasms.
3			60	660	7.1	Ur. p. i. edema collapse.
4	B p. I	$\frac{1}{8}$	60	400	5.1	P. i. marked.
5			60	520	6.6	Hyp. excit. spasms.
6	B p. I	$\frac{1}{4}$	60	502	9.6	V. sl.
7			70	369	7.0	V. sl.
8	B p. I	$\frac{1}{8}$	72	440	10.3	P. i.
9			85	500	12.3	V. sl.

TABLE IV

TEST OF SERIES OF GUM SAMPLES OF VARYING AGE

No.	Appearance of sample	Age of prep.	Propor. bld. vol.	Inj. time in sec.	Wt. of g. p.	Dose in c.c.	Result
A p. 5							
1	Light brown, opalesc. no ppt.	98 days	$\frac{1}{4}$	60	452	4.9	V. sl. effect.
2			$\frac{1}{4}$	60	420	4.6	V. sl. effect.
3			$\frac{1}{8}$	65	485	7.4	V. sl. effect.
4			$\frac{1}{8}$	58	485	7.4	V. sl. effect.
5			$\frac{1}{3}$	80	575	14.6	V. sl. effect.
6			$\frac{1}{3}$	60	465	9.0	V. sl. effect.
B p. 5							
7	Gray opalesc. no ppt.	93 days	$\frac{1}{4}$	55	437	4.8	Ext. p. i. spasms.
8			$\frac{1}{4}$	55	487	5.2	V. sl. effect.
9			$\frac{1}{8}$	60	452	6.9	V. sl. effect.
10			$\frac{1}{8}$	60	452	6.9	V. sl. effect.
11			$\frac{1}{3}$	120	440	11.3	V. sl. effect.
12			$\frac{1}{3}$	78	400	10.0	V. sl. effect.
C p. 5							
13	Gray opalesc. no ppt.	91 days	$\frac{1}{4}$	55	505	5.5	V. sl. effect.
14			$\frac{1}{4}$	60	555	6.0	V. sl. effect.
15			$\frac{1}{8}$	63	525	8.0	V. sl. effect.
16			$\frac{1}{8}$	60	500	7.4	V. sl. effect.
17			$\frac{1}{3}$	65	345	8.8	V. sl. effect.
18			$\frac{1}{3}$	75	400	10.0	V. sl. effect.
D p. 5							
19	Light brown opalesc. sl. ppt.	89 days	$\frac{1}{4}$	60	470	4.6	V. sl. effect.
20			$\frac{1}{4}$	60	495	5.4	V. sl. effect.
21			$\frac{1}{8}$	60	460	7.3	V. sl. effect.
22			$\frac{1}{8}$	55	430	6.6	V. sl. effect.
23			$\frac{1}{3}$	85	380	9.6	Dead 20' *.
24			$\frac{1}{3}$	96	400	10.0	V. sl. effect.
E p. 5							
25	Gray opalesc. mod. ppt.	82 days	$\frac{1}{4}$	60	505	5.4	Nil or v. sl. effect.
26			$\frac{1}{4}$	60	455	5.0	Nil or v. sl. effect.
27			$\frac{1}{8}$	60	460	7.0	Nil or v. sl. effect.
28			$\frac{1}{8}$	55	475	7.1	Nil or v. sl. effect.
29			$\frac{1}{3}$	85	405	10.1	Nil or v. sl. effect.
30			$\frac{1}{3}$	96	350	9.0	Nil or v. sl. effect.

* Autopsy showed death due to vascular rupture and internal hemorrhage.

the other three. The results of the experiment are recorded in Table III.

The effects produced by this sample of gum salt were considerably greater than those following the injection of A p. 1. It is again true that the most marked results are produced by amounts around the dose of $1/7$ blood volume. It is to be especially noted that no really severe anaphylactiform effect has been produced. No dyspnoea, severe respiratory spasms have occurred. It has been the impression of some observers that the older samples of gum salt were the ones causing trouble. In this case, however, we are dealing with a preparation three times as old as that used in experiment I, yet there is no clean-cut difference in toxicity between the two samples.

TABLE V

No.	Appearance of sample	Age of prep.	Propor. bld. vol.	Inj. time in sec.	Wt. of g. p.	Dose in c.c.	Result
F p. 5							
1	Dark	80 days	$\frac{1}{4}$	57	625	6.7	P. i. urinat.
2	brown		$\frac{1}{4}$	60	600	6.5	spasmlab.resp.collapse
3	marked		$\frac{1}{4}$	75	525	7.2	Hyperexcit.
4	ppt.		$\frac{1}{4}$	65	570	8.7	Ext. p. i. collapse sp.
5			$\frac{1}{4}$	115	370	9.3	V. sl. effect.
6			$\frac{1}{4}$	120	360	9.0	V. sl. effect.
G p. 5							
7	Gray	67 days	$\frac{1}{4}$	55	775	8.4	All nil.
8	opalesc.		$\frac{1}{4}$	60	500	5.6	All nil.
9	no		$\frac{1}{4}$	60	395	6.0	All nil.
10	ppt.		$\frac{1}{4}$	60	395	6.0	All nil.
11			$\frac{1}{4}$	85	310	7.2	All nil.
12			$\frac{1}{4}$	120	470	12.0	All nil.
H p. 5							
13	Gray	37 days	$\frac{1}{4}$	55	650	7.1	Resp. sp. ur. shivers.
14	opalesc.		$\frac{1}{4}$	60	700	7.5	Nil.
15	no		$\frac{1}{4}$	66	490	7.5	Dead 24 mon.*
16	ppt.		$\frac{1}{4}$	67	550	8.4	V. sl. effect.
17			$\frac{1}{4}$	108	430	11.0	V. sl. effect.
18			$\frac{1}{4}$	110	460	11.6	Hyperexcit.
I p. 5							
19	Gray	36 days	$\frac{1}{4}$	58	560	6.1	All nil or v. sl. effect.
20	opalesc.		$\frac{1}{4}$	63	580	6.1	Nil or v. sl. effect.
21	mod.		$\frac{1}{4}$	70	700	10.3	Nil or v. sl. effect.
22	ppt.		$\frac{1}{4}$	63	590	9.0	Nil or v. sl. effect.
23			$\frac{1}{4}$	110	460	12.0	Nil or v. sl. effect.
24			$\frac{1}{4}$	110	440	10.3	Nil or v. sl. effect.
J p. 5							
25	Gray	35 days	$\frac{1}{4}$	60	700	7.5	V. sl. effect.
26	opalesc.		$\frac{1}{4}$	55	520	5.7	V. sl. effect.
27	v. sl.		$\frac{1}{4}$	62	550	8.4	V. sl. effect.
28	ppt.		$\frac{1}{4}$	60	575	8.8	V. sl. effect.
29			$\frac{1}{4}$	95	455	11.6	V. sl. effect.
30			$\frac{1}{4}$	90	400	10.0	V. sl. effect.
K p. 5							
31	Brown	34 days	$\frac{1}{4}$	60	530	5.8	V. sl. effect.
32	v. sl.		$\frac{1}{4}$	55	500	5.4	Jerky resp.
33	ppt.		$\frac{1}{4}$	60	470	7.2	Remainder.
34			$\frac{1}{4}$	58	430	6.6	Nil or v. sl. effect.
35			$\frac{1}{4}$	120	430	11.0	Nil or v. sl. effect.
36			$\frac{1}{4}$	90	430	11.0	Nil or v. sl. effect.

* Autopsy showed vascular rupture and internal hemorrhage.

INTRAVENOUS INJECTION OF GUM SALT SOLUTIONS

It was decided that no conclusion could be drawn from the testing of two preparations only. The next step was, then, to study systematically a long series of preparations of different ages with a view toward discovering if any were toxic or if all were as comparatively innocuous as the first two investigated.

The tests of the remainder of the samples in the series are summarized in Table V.

Out of a series of 11 preparations in which in all 66 animals were injected, very few if any perceptibly toxic effects were obtained. The most notable of these occurred in the case of Fp.5, the results of which are shown in Table V, Nos. 1-6. Several of the animals injected with this preparation showed marked peripheral irritation and in two cases quite severe symptoms, including collapse, made their appearance. It is to be noted that this sample had a very bad physical appearance. The color was dark brown and a fairly heavy precipitate was present in the bottom of the flask. This, of course, had been shaken into a uniform suspension before injection. In the total series two deaths resulted. At the time these appeared atypical, autopsy showed them to be due to vascular rupture at some point in the peritoneal cavity, most probably the liver. Summing up it may be said that no marked anaphylactiform effect followed the injection of any of the samples in this extensive experiment.

Test of Gum Salt Solutions Subjected to Cold.—The reports of the deleterious effects of gum injection had only begun to be heard in the fall months during the Argonne-Meuse drive. It is well known that the evacuation in this drive was much slower than in the Chateau-Thierry push and the wounded were in much poorer condition. But the condition of the recipients, while probably the most important factor in the alleged bad effects of the gum injections, cannot be taken into account in this work. It is possible, however, that the cold might have had some effect on the gum solution itself. It was thought that the physical state of the gum might have undergone some alteration as the result of exposure to the cold. Continued exposure to lower temperatures may have induced some phenomenon corresponding to the gelation of certain hydrophile colloids, of which agar is an example. This change might not result in a visible setting as in the latter case, but on the other hand, some alteration in extent of surface or in configuration of particles might change the gum from a harmless to a dangerous substance. Tentatives at experimental approach to this question were made in the following way.

Gum solutions Bp. 1 and Gp. 5 were used in the first experiment. Table II may be consulted in reference to Bp. 1, Table V in reference to the activity of Gp. 5. The former had shown some slight evidence of harmful effect. The latter had proved to be practically innocuous. The solutions were taken from the identical samples employed in the experiment just mentioned.

A freezing mixture, ice-salt, was prepared having a temperature of -12 degrees. Seventy-five c.c. each of Bp. 1 and Bp. 5 were placed in two 100 c.c. Erlenmeyer flasks and the latter surrounded by the freezing mixture for a period of four hours. Examination of the solutions with dark field showed no perceptible change after this exposure to the cold. Both solutions immediately after this treatment were brought to 42 degrees and injected with the technic described above. The results are recorded in Table VI.

TABLE VI

No.	Sol. inj.	Bld. vol. propor.	Inj. time in secs.	Wt. of g. p.	C.c. inj.	Result
1	B p. 1	$\frac{1}{2}$	57	505	5.5	Shiver-hyperexcit.
2	B p. 1	$\frac{1}{2}$	60	485	5.3	Hyperexcit.
3	B p. 1	$\frac{1}{2}$	110	540	6.8	V. sl. effect.
4	B p. 1	$\frac{1}{2}$	60	460	5.6	P. i. hyperexcit.
5	G p. 5	$\frac{1}{2}$	55	420	5.3	Nil.
6	G p. 5	$\frac{1}{2}$	60	430	5.3	Nil.

Several other experiments of a similar nature were attempted with different preparations exposed to different temperatures. In no case was any increase in effect observed. In one series solution Fp. 10 was injected without preliminary warming, after being subjected to 0 degrees temperature for four hours. No marked effect was observed.

Test of Sterility of Samples.—Some of the gum preparations exhibited upon inspection a cloudiness reminiscent of fluids contaminated with bacteria. It was, therefore, considered desirable to test the samples for possible bacterial contamination. These tests were carried out in every case before the bottles submitted to experiment were opened for removal of a portion of the gum for toxicity test. Direct microscopical preparations were made, following which tubes of plain infusion broth were seeded with 1 c.c. of each sample and incubated for four days. Out of a series of 35 samples of gum salt, each of which had been made on a different date, three were found to be contaminated. This was shown both by direct examination and by cultural test. Check cultures of the contaminated samples were at once made to avoid the error of accidental contamination of medium.

Preparations K-p. 10 and O-p. 10 were heavily contaminated with a bacillus of the subtilis group. C-p. 12 was found to contain both staphylococcus aureus and an unidentified slightly motile bacillus. It was thought possible that while the organisms might not be particularly harmful *per se*, complexes of gum-bacteria might be formed which when injected could cause a disruption in the equilibrium of the blood colloids or produce changes at the surfaces of body cells.

The effect of these contaminated preparations on guinea pigs was consequently tried. One of these, C-p. 12, presented a peculiar appearance to the unaided eye. The color of the solution was pearly gray, a consid-

INTRAVENOUS INJECTION OF GUM SALT SOLUTIONS

erable precipitate had accumulated at the bottom of the bottle, while close inspection revealed a large number of evenly suspended, minute, flocculent particles which did not precipitate. Dark field examination indicated these to be clumps of bacteria, predominatingly staphylococcus, in a sort of matrix of amorphous particles.

This sample, C-p. 12, had been brought down from the advanced medical supply dump at Souilly. It bore the date mark of preparation of September 9, 1918, and had evidently been made at the central laboratory. It was subjected to intravenous injection into guinea pigs as follows. The results of the injection are summarized in Table VII.

TABLE VII

No.	Propor. bld. vol.	Inj. time in secs.	Wt. of g. p.	Dose in c.c.	Result
1	$\frac{1}{8}$	60	450	4.2	Hyperexcit. sev. depress.
2		55	505	5.5	V. sl.
3	$\frac{1}{4}$	60	450	5.0	Dead 4' typical shock.*
4		60	445	5.0	Dead 3h. 45' atypical.†
5		60	440	4.7	P. i.
6	$\frac{1}{8}$	60	455	5.3	Urinat. lab. resp.
7		65	450	5.8	Ext. hyper. excit. jerk. resp.
8		60	420	6.4	Ext. hyperexcit. spasm sick.
9	$\frac{1}{8}$	60	410	6.2	Dyspnoea severe effect.
10		55	400	6.0	V. rapid shallow resp.
11	$\frac{1}{4}$	65	480	9.1	P. i. spasm collapse v. severe.
12	$\frac{1}{8}$	97	470	12.0	Edema resp. spasms.

This sample revealed by far the most severe effect of any tested. The shock produced in No. 3 was perfectly typical of anaphylaxis. The autopsy also showed the typical picture. Repeated attempts were made to duplicate this result without success and it was finally concluded that an extraordinarily susceptible animal was being dealt with, this susceptibility being natural or, what is more likely, caused by the pneumonia which was undoubtedly present. On the other hand, a number of the animals injected displayed severe effects. These have been caused by the extensive amount of bacterial protein injected.

Attempts were made to obtain similar effects by seeding sterile harmless gum solution with the microbes isolated from the last studied somewhat toxic sample. The experiment was carried out as follows:

Gum D-p. 5 was chosen for the experiment. In the experiment summarized in Table IV this preparation had shown itself to be entirely harmless for the guinea pig in the doses employed.

A. 80 c.c. of gum salt D-p. 5 were placed in a 100 c.c. Erlenmeyer flask and seeded with 12 mm. loop of *St. aureus* isolated from C-p. 12.

* Autopsy showed extreme emphysema, persistence of heart beat, delayed coagulation of blood. Also extensive pneumonic involvement of left lung.

† Autopsy showed death from vascular rupture—internal hemorrhage peritoneum.

B. Like amount of the same gum sample placed in flask and seeded with 1 c.c. of a broth culture containing the staphylococcus and the bacillus isolated from C-p. 12.

C. 80 c.c. of sterile gum salt, D-p. 12 placed in Erlenmeyer flask as control.

Flasks A, B and C were now incubated and tested at the end of 48 and 96 hours. At the end of 48 hours there was a heavy growth of staphylococcus in both A and B, but no bacillus in B. The control tube, C, remained sterile. At the end of 96 hours the growth of staphylococcus in both flasks was still heavier, and a few bacilli were visible in B. The organisms remained partly in suspension, partly precipitated. It is worthy of note that the suspended floccules present in C-p. 12 were not present in either A or B. The results of the experiment are summarized in Table VIII.

TABLE VIII

No.	Sol. inj.	Hrs. incub.	Proport. bld. vol.	Time inj.	Wt. of $\frac{1}{2}$ g. p.	c.c. inj.	Result
1	A	48	$\frac{1}{2}$	60	410	4.4	P. i.
2	A	48	$\frac{1}{2}$	60	440	4.7	Spasms severe.
3	A	48	$\frac{1}{2}$	65	430	6.6	Sev. resp. effect.
4	B	48	$\frac{1}{2}$	70	470	5.1	V. sl. effect.
5	B	48	$\frac{1}{2}$	60	490	5.2	Resp. spasm.
6	A	96	$\frac{1}{2}$	55	420	4.5	Hyperexcit.
7	A	96	$\frac{1}{2}$	60	490	5.2	V. sl. effect.
8	A	96	$\frac{1}{2}$	75	590	9.2	Jerky resp.
9	A	96	$\frac{1}{2}$	80	485	9.7	V. sl. effect.
10	B	96	$\frac{1}{2}$	50	500	5.4	Resp. spasm.
11	B	96	$\frac{1}{2}$	50	430	5.2	Nil.

While some of the guinea pigs injected showed some effect the result was not nearly so severe as in the case of C-p. 12. It is possible that the agglomerations observed in that sample only occur after the bacteria have been present over a considerable period of time. There was no opportunity to put this conjecture to experimental test.

Gum salt solution B-p. 12 brought down from the medical supply dump of the Justice Group, Second Army, also exhibited the peculiar flocculent suspension observed in the case of C-p. 12. It was not contaminated, nor was there any precipitate in the bottom of the bottle. The preparation had been made and sterilized at the front. On account of the close resemblance of the floccules to those of C-p. 12, it was most carefully tested for toxicity. A series of guinea pigs were injected intravenously as before, but aside from the minor effects observed after the injection of any solution of gum, no serious effects followed.

The two other contaminated samples, K-p. 10, and O-p. 1, were also injected into a series of guinea pigs. The result of the tests is summarized in Table IX.

In two cases out of the eight animals injected severe effects were observed, i.e., in Nos. 2 and 5. The results were not as alarming as in the case of C-p. 12, but it is still worthy of note that some noticeable effect is observed

INTRAVENOUS INJECTION OF GUM SALT SOLUTIONS

TABLE IX

No.	Sol. inj.	Propor. bld. vol.	Inj. time	Wt. of g. p.	c.c. inj.	Result
1	K p. 10	$\frac{1}{4}$	60	460	5.0	P. i.
2	K p. 10	$\frac{1}{4}$	60	400	4.2	Hyp. excit. resp. lab. depress
3	K p. 10	$\frac{1}{2}$	60	580	8.8	Int. hypexcit. p. i. spasms.
4	K p. 10	$\frac{1}{2}$	60	570	8.7	Hyp. excit.
5	O p. 10	$\frac{1}{4}$	60	700	7.5	Spasms p. i. collapse (severe)
6	O p. 10	$\frac{1}{4}$	60	570	6.1	V. sl. effect.
7	O p. 10	$\frac{1}{2}$	60	400	6.0	Hyp. excit.
8	O p. 10	$\frac{1}{2}$	60	350	5.4	Hyp. excit.

in the case of all three of the contaminated samples, while the great majority of sterile preparations tested exhibit little or no result.

Effect of Gum Salt on Rat and Guinea Pig Serum.—It is well known that certain hydrophile colloids, such as agar (Bordet), starch and inulin (Nathan), and pectin (Mutermilch and Kopaczewski) are capable of rendering normal guinea pig serum extremely toxic for homologous animals. Novy and De Kruif have shown that this reaction occurs with greater intensity in the case of rat serum. Thus a 200 gm. guinea pig will tolerate with ease a dose of 4 c.c. or more of normal rat serum. On the other hand, when the serum is first incubated for a short time with a minute quantity of agar, it becomes extremely toxic, killing guinea pigs of the weight just mentioned in dose of from 0.1 to 0.5 c.c. The symptoms and picture at autopsy are not to be differentiated from those of true anaphylaxis.

It has been demonstrated that this reaction, so easily produced *in vitro*, can be produced *in vivo* by the injection of agar which has been brought into a suitable physical state. In both cases some interaction of the foreign colloid with substances in the colloidal state in the serum is responsible for the effects obtained.

Since practically all the preparations of gum examined had proved themselves so harmless for the guinea pig, it was thought desirable to test the effect of this substance on rat serum. The latter is a most delicate indicator of the "disturbing" power of colloids, and it would be interesting if the harmlessness of the gum *in vivo* were borne out by its inability to render toxic the serum of the rat. On the other hand, if it showed itself to possess such power, further careful study would have to be carried out.

The first experiment was conducted as follows: Gum salt solution J-p. 5 had little or no effect when injected into guinea pigs (see Table V, Nos. 25-30). This solution was used as gum sample in this experiment. A number of white rats were bled from the heart, the blood defibrinated by rod, pooled, centrifugated and the serum pipetted off.

A. 1 c.c. of sterile 0.85 per cent. NaCl solution added to 4 c.c. of normal rat serum, placed in water bath at 40, and tested for toxicity after incubation for 30 minutes and 60 minutes.

TABLE X

No.	Inc. time 40 degrees	Sol. inj.	Wt. of g. p.	c.c. inj.	Result
1	30	A	275	2.5	Nil.
2	30	B	275	2.5	Nil.
3	60	A	270	2.5	Nil.
4	60	B	250	2.27	Nil.

B. 1 c.c. G. S. J-p. 5 added to 4 c.c. normal rat serum, placed at 40 in bath, tested as in case of A. intravenous injection.

There was no perceptible difference in the effect of A and B in this experiment. The gum had no more effect than the normal salt solution on the toxicity of the rat serum.

It was thought desirable to test the action of other gums, particularly those which had shown some harmful effect. Further, the negative effect of the gum (if the effect should be in every case negative) would be more strikingly shown by the addition of a positive control. Consequently a 0.5 per cent. solution of agar in 0.85 per cent. NaCl solution was prepared. The agar, 0.5 gm., was cut into small pieces and placed in 100 c.c. of sterile 0.85 per cent. NaCl solution. The mixture was autoclaved for 30 minutes at 120 degrees. When cool, this solution sets to a gel which can be easily shaken up to a semifluid, lumpy mass. The solution, because of its low concentration in agar, will remain liquid at 38-40 degrees for several hours.

TABLE XI

No.	Mixt. inj.	Inj. time	Dose ser. per gm. of g. pig.	Wt. of g. p.	c. c. inj.	Result
1	A	60	.008	250	2.25	Nil.
2	A	60	.012	220	3.75	Nil.
3	B	60	.004	250	1.0	Dead 3' typical.
4	B	60	.003	250	0.75	V. severe shock.
5	B	60	.003	200	0.6	Dead 3'30" typical.
6	B	60	.002	200	0.5	Dead 3' typical.
7	B	60	.001	200	0.35	Dead 4'10" typical.

Gum solution B-p. 1 was used in the experiment. For the effect of this solution on guinea pigs see Table III. The serum obtained in the preceding experiment was divided into two parts and treated as follows:

A. 10 c.c. normal rat serum added to 2.5 c.c. G.s. B-p. 1, placed in cracked ice for two hours, then incubated for 60 minutes at 40 degrees, centrifugated and injected.

B. 7 c.c. normal rat serum added to 1.75 c.c. of agar hydrosol, mixed, placed in cracked ice for two hours, incubated for 60 minutes at 40 degrees, centrifugated and injected.

Results summarized in Table XI.

The experiment just described and summarized in Table XI illustrates strikingly the wide difference of effect of gum and agar on rat

INTRAVENOUS INJECTION OF GUM SALT SOLUTIONS

serum. Agar acting for one hour on rat serum brought it to a toxicity of .0012 per g. of guinea pig. On the other hand, .012 per g. (ten times as much) of the gum-treated serum had no effect.

It is possible that as in the case of so many reactions between substances in the colloidal state an optimum quantitative balance between the reacting elements had not been obtained. To test this the following experiment was devised. Various quantities of gum salt solution were added to constant amounts of normal rat serum. As a positive control a minute amount of agar was added to another tube of serum.

- A. 2.0 c.c. normal rat serum added to 1 c.c. G.S. B-p. 1.
- B. 2.0 c.c. normal rat serum added to 0.28 c.c. G.S. B-p. 1.
- C. 2.0 c.c. normal rat serum added to 0.20 c.c. G.S. B-p. 1.
- D. 2.0 c.c. normal rat serum added to 0.10 c.c. G.S. B-p. 1.
- E. 3.5 c.c. normal rat serum added to 0.07 c.c. 0.5 per cent. agar.

All of the above mixtures were incubated at 40 degrees for 60 minutes, and following that injected intravenously into guinea pigs. The results of the experiment are summarized in Table XII.

TABLE XII

No.	Mixture	Proport. G. s. or agar to serum	Inj. time of mixtures	Wt. of g. p.	c. c. inj.	Result
1	A	1-2	-60'	300	3.0	V. sl.
2	B	1-7		420	2.28	Rapid resp.
3	C	1-10		420	2.20	Nil.
4	D	1-20		380	2.10	Nil.
5	E	1-50	-60'	400	1.0	Sev. shock.
6	E	1-50		300	1.0	Near kill.
7	E	1-50		380	0.8	Sev. shock.

Tables XI and XII indicate that minute amounts of agar can cause intense toxic increase in rat serum, while the gum salt solutions tested in various concentrations produce no appreciable effect on the serum from the same pool.

Similar experiments, again using agar as a positive control, were made with guinea pig serum (homologous serum). Various gum samples were used, *i.e.*, B-p. 12, J-p. 5, and even C-p. 12. The latter might have been expected to have caused a toxic change because of the bacteria present. Such, however, was not the case. Amounts of guinea pig serum up to 5.3, after incubation with gum, were harmless for homologous animals.

Effects of Intravenous Injections of Minute Amounts of Agar on Guinea Pigs.—It might be of interest to demonstrate the effect of very small amounts of agar intravenously injected into guinea pigs and to compare these effects with the slight ones in general produced by gum injections.

Nathan has shown that the power of inulin to render guinea pig serum toxic depends largely on the physical state of the inulin. Similarly the writer, together with Novy, succeeded in demonstrating that agar,

brought into a suitable physical state, can produce the same effect *in vivo* that it produces *in vitro* when mixed with guinea pig serum.

The general method of preparing agar for such injection is as follows: 0.5 per cent. agar-salt solution is boiled, cooled to 40 degrees, and while still liquid is diluted with 6 to 9 parts of sterile NaCl solution. This dilute agar is then subjected to 0 degrees temperature for two hours. It is too dilute to set into a gel, but close inspection reveals that the solution has changed from a uniform gray opalescence to one containing evenly suspended, minute floccules of gel. This suspension, when warmed and injected intravenously, produces severe effects in guinea pigs and in appropriate dose frequently kills them with effects typical of those of anaphylaxis.

The following experiment will illustrate this:

A. 0.5 per cent. agar boiled 10 minutes then cooled to 40 degrees. Five c.c. of above added to 45 c.c. of 0.85 per cent. NaCl solution and placed at 5 degrees for two hours.

B. Same 40 degree agar solution added (5 c.c.) to 35 c.c. of 0.85 per cent. NaCl solution and subjected to cold as in A.

Both warmed to 40 degrees and injected into guinea pigs. The results of this experiment are summarized in Table XIII.

TABLE XIII

No.	Sol. inj.	Inj. time	Wt. of g. p.	Mg. of agar	c. c. inj.	Result
1	A	100	440	5.0	10.0	Dead 20' typical shock.
2	A	115	470	5.0	10.0	Sev. dysp. convulsions.
3	A	45	420	3.25	6.5	Hyp. excit. ext. depress.
4	A	90	490	6.0	12.0	Resp. spasms dyspnoea.
5	B	70	470	6.25	10.0	V. rapid heavy resp. v. sick.
6	B	115	610	7.5	12.0	Dead 23' typical shock.

It will be observed that such small amounts as 5 mg. of agar can cause fatal result when intravenously injected into guinea pigs. It may be remarked here that far larger amounts can be injected with little effect when the undiluted, unchilled hydrosol is used.

It appears that the attainment of an appropriate surface development of the agar particles plays an important rôle in the production of a toxic effect.

Attempt at Production of Agglutination of Guinea Pig and Red Cells with Gum.—At the request of Colonel Cannon such experiments were conducted with various gum preparations both on oxalated guinea pig blood and on the washed red cells of the same species. With high concentrations of gum (1-1 gum-blood) and in certain cases in concentrations of 1-2 and 1-3, some hemagglutination took place. But in general the reaction was feeble and rather easily reversible. The clumps of red cells were not firmly adherent, repeated shaking bringing the cells back into

a suspension from which no clumping but only uniform gradual settling occurred.

Summary and Conclusions.—A large number of preparations of the gum-salt solution made at the central laboratory and used in resuscitation work at the front have been subjected to toxicity tests in guinea pigs. The aim of the experiments was to discover whether these solutions might possess the “equilibrium disturbing” effect that certain substances in the colloidal state show when injected into the circulation.

With one exception no effects of an anaphylactiform nature were observed. Slight symptoms of various kinds which followed the injection of massive doses of certain samples were of so little importance that they could be disregarded.

The exception just mentioned was that of a sample contaminated with staphylococcus aureus and an unidentified bacillus. Severe effects followed the injection of this preparation. One guinea pig succumbed with typical anaphylactic symptoms. It is to be noted that this animal was not a normal one but was shown at autopsy to be pneumonic.

Normal harmless gums seeded with the organisms isolated from the preparation just described showed some increase in toxicity, which was not, however, as marked as that of the original sample.

Out of 35 samples tested for sterility, 3 were found to be contaminated. This is a serious indictment of methods of control of sterility used by those making the gum solutions.

Attempts to produce a toxic state in gum solutions by subjecting them to cold failed.

Attempts to make normal rat and guinea pig sera “anaphylatoxic” with various samples of gum did not succeed. This furnishes important confirmatory evidence of the harmlessness, as far as the anaphylactic effect is concerned, of the gum solutions.

THE TREATMENT OF BURNS

AN EXPERIENCE IN THIRTY-ONE CASES DUE TO FOREST FIRES

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OF DULUTH, MINN.

THE forest fires of October 12, 1918, brought to the hospitals of Duluth and neighboring towns many cases of severe burns. From the morning of October 13, it was my good fortune to have charge of the burned and refugee patients during their treatment at St. Luke's Hospital. We have records of 31 cases of extensive burns which were cared for largely with paraffine treatment. It seems desirable to put our experience and conclusions on record. A number of physicians, especially Drs. F. M. Turnbull, H. Klien, A. H. Schwartz, D. L. Tilderquist and Homer Collins, were of most material assistance in the preliminary care. The regular hospital nursing staff, together with several Red Cross nurse's aids, were tireless in helping with the dressings.

The chart explains the extent of the burns, duration of treatment, complications and results. In addition to the shock resulting from the burns, all of the patients had suffered from severe exposure. Chilling together with irritation by smoke caused a most persistent bronchitis in nearly all cases.

Three types of cases terminated fatally: 1. Those where burns involved over one-half of the body, these died within six hours. Cases 16-30.

2. Those suffering from the effects of severe pulmonary congestion. Cases 1, 12 and 13. Case 1 suffered comparatively little from external burns, but had inhaled flame and smoke. He presented a most peculiar condition of excitement and delirium on admission. After receiving $\frac{1}{4}$ grain morphine, exhaustion and coma with noisy stertorous breathing followed. In spite of vigorous stimulation—coffee per rectum, camphorated oil and pituitrin hypodermically—the man died in a few hours. Cases 12-13 presented extensive burns, but the most striking feature was massive pulmonary congestion with stertorous breathing and the immediate cause of death was œdema of the lungs. Though both these women lived for several days, no treatment was of any avail.

3. "Late toxæmia" and exhaustion, a condition we could neither explain nor apparently influence, caused death in several cases (2, 15, 18, 26). Most of them showed temporary improvement and there was some healing about the burns. The general condition of these patients, however, was never satisfactory and there was little definite reaction from the primary shock and depression.

Routine urine examinations were made in all the cases but aside from an occasional trace of albumen there seemed to be but little urinary dis-

turbance. After a varying period the patient became toxic and weak, sloughs extended and there was no response to the usual forms of stimulation. Blood transfusion was not tried but might have been of value.

A number of other patients were in a more or less precarious condition for the first week or so, after which improvement both of general condition and of the burns was progressive. Tonics, especially iron and strychnine, were used freely.

In the first aid treatment we had two considerations.

1. *Dressings.*—Nearly all of our cases had been dressed with Carron oil on admission. This did not give comfort, was dirty and disagreeable, and at the suggestion of Doctor Schwartz we dressed the later cases with gauze saturated with 10 per cent. sodium bicarbonate solution. This gave immediate relief, and, if kept moistened at frequent intervals, was much more comfortable than anything else. In our experience it is the dressing of choice for first aid, since it is always available, is easily applied, is not mussy or dirty and gives prompt relief. We believe that the complicated technic of paraffine is best reserved till the initial shock and depression is overcome, if this be at all marked.

2. *Relief of Pain; Treatment of Shock.*—Pain is overcome to a great extent by a suitable dressing. In extensive cases removal of blisters and the rather complicated dressings are not advisable, for reasons already mentioned. Ten per cent. sodium bicarbonate solution on gauze is easily applied and gives instant relief. We ordered the dressings moistened every hour or two for the first thirty-six hours.

Morphine is usually necessary and should be given in efficient amounts. The effect must be closely watched and stimulation may be necessary on account of severe depression. We used heat externally, elevation of the feet, hot coffee per rectum, camphorated oil hypodermically, and strychnine, in some cases. Hot drinks including tea, chocolate or water were given at hourly intervals.

A few patients were extremely restless and unable to sleep in spite of rather heavy doses of morphine. These we found responded to chloral hydrate by mouth or rectum. More than a half of the patients were in a precarious condition for a number of days, and, as already noted, several failed to react and died.

The after care is long and tedious. Within forty-eight hours we were able to go over all except the obviously hopeless cases, remove blisters and substitute paraffine. We used the metal atomizer, but had great difficulty with rubber bulbs. The use of a portable air tank simplified the technic. When this was pumped up to from 10 to 20 pounds pressure we were able to keep a constant spray of paraffine and dress the large burns rapidly and painlessly. "Dichloramine T" in oil was sprayed on the surface before the paraffine but it was difficult to see any benefit and the patients complained greatly of the pain. During the period of sloughing, wet dressings of potassium permanganate were used freely

ARCHIBALD L. McDONALD

No.	Sex	Age	Extent of Burns	Complications	Treatment	Date of discharge or death	Result
1	Male	50	Hands, face	Pulmonary congestion, shock, delirium, coma	Morphine and coffee stimulants	Oct. 13, 1918	Died
2	Male	20	Hands, face and head	Sloughing, gangrene, hemorrhage, pulmonary congestion, depression	Paraffine, wet permanganate	Oct. 29, 1918	Died of toxæmia
3	Male	60	Face, head, neck, many areas of back, both hands, legs	Gangrene, sloughing of fingers and thumbs	Paraffine and permanganate	Mar. 15, 1919	Loss of hands
4	Male	21	Both hands	None	Paraffine	Oct. 20, 1918	Good
5	Male	25	Face and both hands	None	Paraffine	Oct. 29, 1918	Good
6	Male	72	Hands, large areas of back and thigh	None	Paraffine, skin graft, adhesive	Dec. 10, 1918	Good
7	Male	45	Face, both hands	Eye and ear	Paraffine	Dec. 13, 1918	Good
8	Male	40	Face, both hands and leg	None	Paraffine	Nov. 25, 1918	Good
9	Male	50	Both hands, large area on back and side	Influenza	Paraffine and adhesive	Dec. 15, 1918	Good
10	Male	62	Hands, thigh and leg	Varicose veins on leg	Paraffine and adhesive	Dec. 1, 1918	Good
11	Male	45	Head, face, both hands, legs to knee and thighs	Shock	Paraffine	Dec. 11, 1918	Good
12	Female	45	Both hands, limbs, face and neck	Pulmonary congestion, shock and depression	Morphine stimulant	Oct. 14, 1918	Died, pulmonary oedema and shock
13	Female	19	Face, head, chest, hands, arms and feet	Pulmonary congestion, shock and depression	Morphine stimulant	Oct. 16, 1918	Died, oedema of lungs and shock
14	Female	28	Face, hands and legs	Pulmonary congestion, bronchitis	Paraffine	Nov. 15, 1918	Good
15	Female	44	Arms and entire body	Temporary improvement, later hemorrhage, depression and toxæmia	Paraffine and stimulation	Oct. 23, 1918	Died, toxæmia
16	Female	35	Deep burns on body, arms and face	No reaction	Morphine	Oct. 13, 1918	Died
17	Female	38	Deep burns on thigh, back and arm	Influenza three weeks, no progress, sloughing	Paraffine, iodoform, adhesive	Feb. 14, 1919	Good
18	Female	38	Right hand, arm, both legs, abdomen	Deep sloughs, late depression and toxæmia	Paraffine, permanganate	Nov. 11, 1918	Died, toxæmia
19	Female	51	Both hands, feet and ankles	Bronchitis	Paraffine	Nov. 23, 1918	Good
20	Male	10	Head, face, hands and legs	None	Paraffine not consistent also unguentine	Dec. 1, 1918	Fair; scars

	Sex	Legs and thighs	Temporary contraction of knees later overcome	Paraffine	Date	Result
21	Female	9	None	Paraffine	Dec. 15, 1918	Good
22	Female	12	None	Paraffine	Nov. 8, 1918	Good
23	Female	5	Depression, influenza	Paraffine	Dec. 5, 1918	Died
24	Male	1	None	Paraffine	Oct. 28, 1918	Good
25	Female	48	Influenza	Paraffine	Dec. 15, 1918	Good
26	Female	10	Hemorrhage, poor condition, toxæmia	Paraffine	Dec. 3, 1918	Died
27	Female	12	None	Paraffine	Dec. 1, 1918	Good
28	Female	8	None	Paraffine	Dec. 10, 1918	Good
29	Female	5	None	Paraffine	Dec. 15, 1918	Good
30	Female	4	Congestion and shock	Morphine, stimulants	Oct. 13, 1918	Died
31	Female	8	None	Paraffine	Dec. 15, 1918	Good

and kept hot and moist. The surfaces quickly became clean, the sloughs separated rapidly, and new epithelium formed at the edges.

As soon as possible paraffine was substituted again. In a few instances where it was difficult to use wet dressings, the surfaces were dusted with iodoform and boracic acid powder, which seemed much preferable to the Dichloramine T.

Daily dressings were necessary in all cases, since there were always sloughs to remove or purulent secretions collected under the paraffine. We used the commercial paraffine melted in a water bath and sprayed in the apparatus as already described. Considerable care is necessary to get a layer of paraffine the proper thickness, since if too thick it falls off and if too thin is difficult to remove. Various mixtures of paraffine with wax or special antiseptics are discussed in some detail by Sherman.¹ Since the paraffine coating comes in contact with the surface granulations only, antiseptics incorporated in the dressing can have little or no influence and are unnecessary. Special mixtures of paraffine and wax may present some advantages in adhering to the surface but our experience with commercial paraffine of comparatively low melting point was entirely satisfactory. It should be applied by means of an atomizer with from 10 to 20 pounds of pressure from an air tank. This method is simple, rapid and practically painless, which can not be said of the application with a brush. Our results were best where the paraffine was not covered by dressings. This was evident in the burns on the backs of hands or on the legs where the bedding could be held away by a cradle. In these cases the healing was rapid, there were no exuberant granulations, and the resulting skin soon became firm and elastic. Even where there had been extensive sloughing, scarring was negligible and there were no serious contractions of cicatricial tissue. Where the paraffine had to be covered by dressings, it was preferable to any ointment on gauze. Various preparations, such as unguentine or boracic acid ointment, were tried in a few instances or in certain areas, but healing was never as satisfactory as with paraffine or adhesive strapping. There were more exuberant granulations and even where the ointment was thickly applied the surfaces were sticky and the gauze seemed to interfere with epithelial growth. We came to the conclusion that any paste or salve applied on gauze was objectionable.

Adhesive strapping over the raw surface was used at first for certain burns on the back, shoulders, or arms, where the paraffine was not suitable. Healing was fully as satisfactory as with the paraffine and much more so than when an ointment was used with gauze. Strips of Z.O. adhesive about one-quarter inch wide were used to cover the area, leaving narrow openings between, then a few layers of gauze to absorb secretions are held with adhesive or a bandage. The whole dressing is easily removed every second or third day, there are no exuberant granula-

¹ Surg., Gyn. and Ob., vol. xxvi, No. 4.

tions, and epithelial growth is rapid. Later the method was used in areas of considerable size, 6 by 3 inches in one case, with great satisfaction. This method of dressing raw or granulating surfaces has been described many times and is worthy of more extensive use. I have since used it exclusively on small burns and have secured prompt healing. The dressing is comfortable, not bulky, and easily changed, new epithelial growth is rapid and is protected from all irritation.

Skin grafting by Reverdin flaps was tried in case 6, with open air under a screen. The attempt was unsuccessful, but adhesive dressing was later substituted followed by rapid healing. Unfortunately a number of patients developed influenza during the course of treatment. It was noted in all cases that healing practically stopped till recovery was complete.

CONCLUSIONS

In the first aid care of extensive burns, the dressing with gauze soaked in 10 per cent. or stronger sodium bicarbonate and kept moistened is the simplest and gives greatest comfort. This is preferable to attempts at a more complicated technic. Morphine should be used to give rest but must be administered with care since there is often severe reaction and depression and the drug may do harm. Treatment of shock with posture, heat, hot drinks and stimulants may be necessary.

Paraffine is much preferable to gauze with oily dressings and should be substituted as soon as possible, at least within thirty-six hours. With the use of the air pump and atomizer the method can be simplified and rendered quite painless, dressings on gauze should be abandoned.

Dichloramine T in oil is painful and of slight value. If there is extensive slough, wet dressings or antiseptic powders are preferable.

The use of adhesive strapping over the raw surface is highly satisfactory and simplifies the treatment since dressings may be extended to two or three days.

The general conditions of the patient must be carefully followed and built up by stimulants, tonics or transfusions.

Skin grafting is rarely necessary nor does it offer much advantage to the healing with paraffine or adhesive.

THE INITIAL TREATMENT OF WAR WOUNDS INVOLVING THE KNEE-JOINT

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THIS paper will be more intelligible if it is introduced by definitions of a few of the terms employed in war surgery. For example:

1. A *perforating wound* is that which goes through and through and which has, therefore, no retained missile.
2. Conversely, a *penetrating wound* has a wound of entrance but none of exit. The missile is retained.
3. *Débridement* consists of the excision of the injured and contaminated tissues, either soft or bony, of a wound track. It implies, as a rule, the removal of the missile and of other foreign bodies, such as clothing.
4. A *primary suture* is a complete closure done at the time of an initial operation.
5. A *delayed or retarded primary suture* is a complete closure done from three to five days after an initial operation.
6. A *secondary suture* is a complete closure done ten or more days after an initial operation. Both delayed primary and secondary sutures imply that, at the initial operation, a wound has been left open for drainage.
7. *Bullet wound* signifies a wound made by a revolver or machine gun. Shrapnel balls are practically a thing of the past.
8. *Shell wound* signifies a wound made by a fragment of the casing of a high-explosive shell.

This study of knee-joint wounds is based on cases coming to an Evacuation Hospital, cared for either by myself or by one of my associates. All were fresh from the battlefield, with the primary dressing still in place. On the average they have come to the operating table fifteen hours after being wounded, three hours and thirty-seven hours being the two extremes.

I. STATISTICS ON TYPE OF MISSILE

In this respect the cases may be differentiated:

Bullet wounds without fracture	6
Bullet wounds with fracture	18
Shell wounds without fracture	22
Shell wounds with fracture	42

2. STATISTICS ON TYPE OF WOUND

Perforating without fracture	14
Perforating with fracture	10
Penetrating without fracture	10
Penetrating with fracture	46
Gutter without fracture	4
Gutter with fracture	4

WAR WOUNDS INVOLVING THE KNEE-JOINT

3. STATISTICS ON TYPE OF FRACTURE

Fracture, femur	30
Fracture, tibia	6
Fracture, patella	10
Fracture, femur and patella	4
Fracture, femur and tibia	4
Fracture, femur, tibia and patella	6

4. SUMMARY OF STATISTICS

Let me condense these findings in this way :

(1) Shell wounds (72 per cent.) are more common than bullet wounds.

(2) Fracture in the joint (68 per cent.) is more common than non-fracture.

(3) Penetrating wounds (70 per cent.) are more common than perforating.

(4) Penetrating wounds usually fracture. In other words, a missile which hits the bone usually stops (82 per cent.).

(5) Fracture of the femur is the most common fracture (48 per cent.).

(6) The most frequent lesion, then, is a penetrating shell wound with fracture of the femur.

5. GENERAL RULES FOR TREATMENT OF ALL WOUNDS OF KNEE-JOINT

Certain general rules apply in the initial treatment of all wounds of this joint. I would offer the following:

A Röntgen-ray examination should precede every operation.

Every knee-joint operation should be done with a tourniquet. Preliminary extrusion of blood with an Esmarch bandage, winding from the foot upwards, is desirable. A dressing is to be applied, at the conclusion of an operation, before the tourniquet is removed.

In case an error in diagnosis is made whereby an intact joint is inadvertently opened, one should immediately suture the false opening.

A culture should be made of every opened joint. Immediate information may be had from a smear. (I regret to say that this rule was broken in many of the cases in this series.)

Ether is not an antiseptic. If joint irrigation is necessary, saline solution serves every purpose. The retention of antiseptic fluids in a joint is contra-indicated.

Wicks, rubber tubes, or strands of silkworm gut may be placed in the periarticular tissues to the synovia but should not enter the joint.

At the time of operation a definite policy of treatment and of after-treatment should be adopted. The incision to be used, the necessity of resection or of amputation, the matter of open capsule or of closed capsule, the decision for or against post-operative mobilization—these must be items in an intelligent, clear-cut scheme. Otherwise, a surgeon

may spend some time in careful débridement, only to find that amputation above the knee is necessary. Another may not have determined whether he is trying for a movable or for a stiff joint.

Cases are best kept under the observation of the operator for at least ten days after operation.

6. NON-OPERATIVE AND OPERATIVE TREATMENT OF CLEAN, PERFORATING BULLET WOUNDS

The method of treatment of a fresh wound of the knee-joint depends primarily on the presence or likelihood of sepsis. Frank sepsis seldom occurs in the early hours after injury; latent sepsis is to be feared if the preoperative period has been long or if the missile is dirty. Shell fragments are more prone to cause sepsis than are bullets. Secondly, treatment depends on the existence of fracture, the retention or non-retention of the missile, on the scope of the wound and on the general condition of the patient; for these factors modify the amount of débridement, the nature of an incision, the time to be expended.

If the presence or likelihood of sepsis is of primary consideration, our cases divide themselves summarily into two classes:

1. Perforating bullet wounds, usually clean, and
2. All other wounds, prospectively septic.

Bullet wounds of the knee cause joint infection in only about ten per cent. of the cases in which this lesion prevails. Yet bullet wounds in soft tissues are rarely sterile,* so that we must fall back on the established fact that the knee-joint itself can overcome low-grade infection. Bullets cause less splintering of bone than do shell fragments.

I believe, therefore, that in the absence of acute inflammation, a knee-joint which exhibits a perforating wound, without extensive fragmentation, caused by a bullet, may be left alone. Otherwise, with every penetrating or perforating wound, the knee-joint should be opened.

Usually, however, even the simple, perforating bullet wounds are accompanied by a considerable bloody exudate into the joint cavity. It is well, then, to adopt one of the two following methods:

(1) One may aspirate, make a culture of the aspirated fluid and immobilize on a posterior wire (Cabot) splint. After a few days active movement may be inaugurated. Reaccumulation of fluid suggests, of course, further aspiration. Oncoming sepsis in the joint is a signal for free incision.

(2) One may excise the peri-articular tissues about the entrance and exit wounds, allow the joint exudate to escape and immediately suture tightly the three layers—synovia, capsule and skin. It is legitimate, before suturing, to wash the joint cavity through a catheter.

* Of one hundred consecutive cases, many of which were bullet wounds, B. Welchii was recovered in eighty-five.

WAR WOUNDS INVOLVING THE KNEE-JOINT

7. OPERATIVE TREATMENT OF ALL OTHER TYPES OF WOUND

a. General Outline of Operative Technic.—An operation, roughly, comprises the following steps:

(1) Application of Esmarch bandage. Application of tourniquet.

(2) Removal of Esmarch bandage.

(3) Preparation of operative field.

(4) Débridement of missile track, both soft tissues and splintered, unattached bone fragments. Each fragment is removed which has the ear-marks of a prospective sequestrum. Evacuation of fluid and blood clot.

(5) Removal of missile, if it be present, together with bits of foreign material carried in with the missile. It is seldom difficult to find the missile in this particular joint. It is fair to say that a clean missile—a bullet—imbedded in bone is often tolerated. Yet even missiles of this category would best be removed unless their removal involves marked bone destruction. It is of paramount importance to remove such foreign material as bits of clothing.

(6) Irrigation of the joint. Personally, I irrigate only septic or dirty joints.

(7) Complete or partial closure of synovia, capsule and skin.

(8) Application of dressing and sometimes of a splint. The customary dressing is dry gauze or gauze wet in Carrel-Dakin solution.

(9) Removal of tourniquet.

b. The Several Incisions.—In opening a joint it is essential to procure a complete approach to all injured areas. Whenever possible, one should make first a liberal lateral incision well outside the patellar edge, incorporating in the incision the entrance wound of the missile. If this be done, a single incision may suffice for the several operative steps. Sometimes, in long ranging wounds, this is impossible and the incision is made through the exit wound or through uninvolved tissue.

If a single lateral incision gives inadequate access, a second lateral incision may be made beyond the opposite patella edge. Better still, one may employ the familiar U-shaped incision, cutting the patellar tendon close to its insertion, but cutting it in a somewhat oblique direction in order to give a broad surface for later coaptation. A missile lying free in the joint may usually be extracted through a single lateral incision.

Never hesitate to make a U-shaped flap for cases of extensive injury. Never fail to resuture the patellar tendon. In so far as is expedient resuture the lateral aspects of the flap.

A median incision, splitting the patella longitudinally, has not been used in any of the cases in this series.

c. Débridement.—To procure adequate débridement one must always follow the missile track. It may be found desirable, secondarily, to remove a missile through a counter-incision; but do not acquire the habit of merely cutting down through clean tissue over a foreign body.

For a missile lodged proximally in condyle or tuberosity, the ideal operation is to débride the track to the bone and to chisel out both missile and adjoining bone *en masse*. A margin of an eighth of an inch of good bone should be removed with the missile. This method is preferable to that of first removing the missile and then attempting to remove dirty bone with a curette.

d. Fractured Patella.—Avoid resection of the patella. Dirty bone along the edges of the track may be rongeured away. If the broken fragments are large, suture the periosteal edges with catgut. For extensive destruction perform a subperiosteal resection.

e. Resection.—In the past, primary resection of the knee-joint has been common both in clean and in infected cases. This teaching has been supplanted by the following:

Avoid primary resection of the knee-joint. It is indicated only for complete or nearly complete destruction, in clean cases, of the lower end of the femur or of the upper end of the tibia. A movable joint seems to be a possibility if two-thirds of either or both of these surfaces remain intact. After resection the knee-joint should be immobilized at an angle of 35 degrees.

f. Amputation.—One must consider primary amputation, rather than simple drainage or resection, for a streptococcus infection of the joint or even for a gas bacillus infection. For other less critical infections, amputation, if necessary, may be done as a secondary operation. Primary amputation, in short, is demanded for two conditions only: Severe joint infection and for complete blood-vessel destruction in the popliteal region.

8. CLOSURE

a. Primary Suture.—If our operation has been other than amputation we are confronted with the question of joint closure. The operative wounds may be closed by primary, by delayed primary or by secondary suture; or they may be left open for a more protracted period for the sake of drainage. We are advised by the army authorities that the capsule, but not the outlying soft tissues, should be closed by primary suture when possible. When, then, is it possible?

Primary suture is possible except when there is:

(a) Infection with streptococcus, staphylococcus, gas bacillus or other similar noxious organism, shown by smear or by culture.

(b) Extensive destruction of capsule.

(c) Large or dirty missile, especially a fragment of shell.

It is possible but not definitely indicated when there is a large amount of fluid and blood clot in the joint.

b. Delayed Primary and Secondary Suture.—If primary suture is contra-indicated, one must then decide, for each individual case, whether the

joint may be closed by delayed primary suture, by secondary suture or must be left open more or less indefinitely. Setting aside the mechanical difficulty of loss of capsule, the question becomes one of the time required to abort or eliminate infection or to get rid of superfluous blood clot and fluid. In other words, a joint must be relatively sterile and relatively empty before it may be closed; suppuration must have ceased; especially must the discharge from the joint give a negative culture for streptococcus.

Delayed primary suture gives an end result as good as that of primary suture. By delayed primary suture the end result is attained more speedily. Delayed primary suture largely eliminates the difficulty of diagnosing prospective sepsis. In my experience the danger of infecting a clean joint, which has been left open, is nil. For these reasons, in my own cases, I am leaning more and more away from primary suture towards delayed primary or secondary suture. I close by primary suture only two types of lesion: (1) Wounds, with little or no fracture, which are sterile on smear. These are usually penetrating bullet wounds. (2) Joint resections.

To these narrowed limits some of my associates would not agree. They are inclined to adhere more rigidly to the specifications set forth under 9, *a*. And it is true that one sees cases like those described as Cases 9 and 10 make an excellent recovery after being closed by primary suture.

c. Frank Sepsis.—Yet when I am in doubt I leave an opening. If frank sepsis exists, it is desirable to have liberal drainage at either side of the patella—so liberal that it drains both the lateral aspects of the joint and the suprapatellar pouch. Drainage may be needed for a considerable time and one must be on his guard against pocketing in the posterior portion of the joint, in the calf of the leg or in the thigh. If frank sepsis does not exist, a shorter incision at one or the other side of the patella suffices—preferably an incision on the side of the entrance wound which exposes, if such exist, injured bony areas. If the incision has been extensive, if one has used, for instance, a U-shaped incision, it is customary to resuture in part. The synovia may be closed with continuous catgut, the capsule with interrupted catgut, the skin with silkworm gut. The patellar tendon and that portion of the capsule immediately adjacent should always be resutured.

Drainage through the posterior aspect of the knee-joint, as an initial procedure, is indicated only when the wounds of entrance or exit involve this region. If such involvement is present, and wicks or tubes are placed to the capsule posteriorly, one must bear in mind the possibility of secondary hemorrhage. Personally, I use no wicks or tubes in the popliteal space. A wide-open, posterior wound, in itself, has sufficed.

So much for the question of closure. It is closely affiliated with the problem of mobilization and immobilization.

9. IMMOBILIZATION AND MOBILIZATION

A tightly closed synovia connotes temporary immobilization. With two exceptions, an open synovia connotes immediate, conscientious, systematic movement. The exceptions are these:

a. If there is extensive destruction of joint surface, it is necessary to immobilize, even though the synovia is not completely closed. Conversely, in the presence of slight bone injury, if one is aiming for a movable joint, immediate movement is advisable.

b. If there is complete fracture of the patella or if there is an injury or an incision which severs either the patellar or quadriceps tendons, it is necessary to immobilize, even though the synovia is not completely closed.

The exceptions we have noted are illustrated by Case 11 or by Case 12.

Let me make this rule more specific, more emphatic, by looking at it from the reverse direction. Temporary immobilization (splint) is indicated for: *a.* Closed synovia, including non-operative cases (Case 2), joint resection, and all other cases closed by primary suture (Case 7). *b.* Complete fracture of the patella or injury or incision which severs either the patellar or the quadriceps tendons (Case 5). *c.* Extensive destruction of joint surface (Case 12).

Mobilization (no splint) is indicated for: *a.* Septic joints. *b.* All cases, except those enumerated above, treated by delayed primary or by secondary suture (Case 8).

Immobilization is happily secured by a Thomas splint slightly bent at the knee or by a posterior wire (Cabot) splint. The Thomas splint affords traction; the Cabot splint does not. Simple cases should be immobilized for at least three days. Thereafter, movement must be gradual. Too free movement leads to accumulation of fluid in the joint.

Undue distention of the joint capsule at once suggests aspiration. Too little effort is made to relieve synovitis or hæmarthrosis in this way. One may aspirate on slight provocation and culture. If the aspirated fluid shows gas bacillus, staphylococcus, streptococcus or other virulent organism, the joint must be opened. Diplococcus alone does not warrant opening a joint. Yet, even in the absence of the more virulent organisms, I have not infrequently made an incision, to be closed a few days afterwards. My results have been satisfactory. Here again, I lean towards delayed primary suture.

If mobilization has been elected, it must be begun within a few hours after the operation, as soon as a patient is out of his anæsthetic, and must be performed systematically and conscientiously. If the joint is allowed to rest immobile for two or three days—even for twenty-four hours—it becomes recalcitrant. It resents any attempted movement—becomes red, swollen and tender. Usually the attempt must be temporarily or permanently abandoned. On the day of the operation, then, and from two

WAR WOUNDS INVOLVING THE KNEE-JOINT

to four times a day thereafter, under supervision, the patient is instructed to lie flat on his back, lock both hands at the posterior surface of the lower thigh and elevate to a right angle both leg and thigh, the knee being in extension. Thereupon, with the thigh still upright, the leg is allowed to drop until it is at least horizontal; better still, it is allowed to drop until the heel is within a few inches of the bed. During this movement, at first, the surgeon must place the palm of his hand under the heel to give partial support.

Most patients are fearful of this procedure. They complain, however, of stiffness rather than of severe pain, and with initial coaching, assistance and encouragement, can easily be taught to perform the manoeuvre. A patient should be made to walk, with a cane, on the second or third day after operation. The first day he takes a few steps, the next day he walks around his bed, the third day, perhaps, the length of the ward. Once only I have seen a slight chill and an elevation of temperature (104 degrees) follow this procedure. The following morning the temperature had subsided.

After delayed primary or secondary suture has been performed, one must regulate motion carefully. We have here a condition analogous to that described in Case 13.

Mobilization is especially important in septic joints. Immobilization of a septic knee is often a forerunner of amputation. Adequate drainage of a quiescent knee is so difficult that a profound and obstinate sepsis, with joint erosion, is apt to develop. Pus pockets are discovered. Septicæmia ensues.

Per contra, mobilization cures sepsis. Active joint movement squeezes out joint pus in a surprisingly effective way and, in many instances, leads to a rapid subsidence of acute symptoms. Mobilization prevents stiffness. Employed from the beginning, it gives mobility without undue discomfort after a relatively brief interval—often after a few days. The result is quite in contrast with that of a splinted patient, with his stiffened, sensitive knee, who must recover strength, reacquire, if possible, motion in his joint, and undergo, at best, a protracted convalescence.

The following case reports illustrate a few of the methods advocated and some of the results secured in this series:

CASES I and II.—*Method employed for simple perforating bullet wounds.*

CASE I.—Perforating bullet wound passing through crural pouch. Five hours old. No culture. *Operation.*—Entrance and exit wounds excised. Closed tightly. Thomas splint. Movement begun after five days. Normal convalescence. Reported three weeks later that he was walking and had no material symptoms from knee.

CASE II.—Perforating revolver bullet passing beneath patella. No fracture. Slight hæmarthrosis. Eighteen hours old. No culture. *Operation.*—None. Aspiration not deemed necessary. Thomas

splint applied. Discharged from hospital two days later. Knee doing well.

CASE III.—*Method employed for long, ranging wound.* Perforating shell wound. Small fragment. Duration not known. Entrance: Left leg, middle third, inner surface. Passed upwards, drilling tibia, external condyle and outer edge of patella. *Operation.*—U-shaped incision. Loose bits of external condyle removed. Patellar edge rongeué. Joint irrigated. Patellar tendon sutured. Incision on outer side left partly open for drainage; closed on inner side. Entrance wound debrided. Rubber tissue drain. Cabot splint. Discharged from hospital after two days. Doing well.

CASE IV.—*Débridement en masse of missile lodged proximally in condyle or tuberosity.* Penetrating shell wound, external aspect of knee. Sixteen hours old. Röntgenogram shows small piece of shell located in central portion of external condyle. Extensive fracture of external condyle. *Operation.*—U-shaped incision including entrance wound. Patella thrown upwards. Knee-joint flexed. Portion of external condyle with shell fragment chiselled out en masse. Inner side of incision resutured in layers. Patellar tendon resutured. Outer side of incision left open for drainage. No splint. Loose dry gauze dressing. *After-treatment.*—Patient encouraged to move knee. Abundant serous discharge. No infection. Discharged from hospital four days after operation in good condition.

(If this patient had been under my care, I should have employed a lateral incision and have held the man until the time was ripe for delayed primary suture; a U-shaped incision suggests temporary immobilization.)

CASE V.—*Suture of fractured patella.* Perforating bullet wound through the patella. Nineteen hours old. Considerable fluid in joint. Röntgenogram shows patella shattered. *Operation.*—U-shaped incision. Joint evacuated and washed with ether. Periosteum of patella sutured with catgut. U-shaped incision resutured, leaving strands of silkworm gut in the superficial tissues. Cabot splint. Patient discharged from hospital the ensuing day in good condition.

In Case V the culture from the joint was negative.

CASE VI.—*Amputation for severe infection.* Gutter wound caused by shell fragment. Quadriceps tendon torn away and joint opened widely. Joint infected with gas bacillus. Röntgenogram shows fracture of the femur just above the condyles. *Operation.*—Guillotine amputation of lower third of thigh. *After-treatment.*—Discharged from hospital, in good condition, four days after operation.

CASE VII.—*Simple primary suture.* Penetrating shell wound. Fifteen hours old. Small amount of fluid in joint cavity. Röntgenogram shows small foreign body lying loose between condyles. No fracture. *Operation.*—Lateral incision including entrance wound. Debridement of track. Joint fluid evacuated. Foreign body removed. Wound closed tightly in layers. Thomas splint. *After-treatment.*—

WAR WOUNDS INVOLVING THE KNEE-JOINT

Gradual motion begun in joint after three days. Discharged from hospital ten days after operation. No untoward symptoms.

CASE VIII.—*Delayed primary suture.* Penetrating shell wound, opposite external condyle. Six hours old. Röntgenogram shows missile lodged against outer surface of condyle. No fracture. *Operation.*—Short lateral incision including wound of entrance. Débridement of track. Removal of foreign body. Smear shows no organisms. Wound left open. Active motion of joint inaugurated. *After-treatment.*—Four days later a culture of joint excretion gave no growth. Knee comfortable. Opening already partly obliterated by granulation. Opening closed in layers; catgut for synovia and for capsule, silkworm for skin. Discharged from hospital five days after operation in good condition.

CASES IX and X.—*Disillusionment sometimes encountered after primary suture.*

CASE IX.—Perforating shell wound, entering opposite internal condyle. Twelve hours old. Röntgenogram shows slight fracture of internal condyle. *Operation.*—U-shaped incision. Fluid and blood-clot evacuated. Loose fragment of internal condyle removed. Wound closed tightly. No culture taken. *After-treatment.*—Three days after operation violent inflammatory reaction in knee. Culture from aspirated fluid shows streptococcus. Amputation at mid-thigh. (This patient had also a penetrating wound of the spinal canal from which he developed a fatal attack of meningitis.)

CASE X.—Penetrating shell wound with fragment lodged in patella. Twelve hours old. Röntgenogram shows compound, comminuted fracture of patella. *Operation.*—U-shaped incision. Shell fragment removed. Patella reformed. Patellar tendon resutured and wound closed by primary suture. *After-treatment.*—Three days later joint badly infected. No report on culture; probably staphylococcus. *Second Operation.*—Patella taken out. Lateral incisions for drainage. Carrel-Dakin tubes. Cabot splint. Patient evacuated a few days later. No later report. He unquestionably developed much erosion of the knee-joint and probably came to amputation.

CASE XI.—*Drainage posteriorly by wide open wound without tubes.* Perforating shell wound. Entrance in popliteal space. Exit anteriorly near the outer, lower corner of the patella. Eleven hours old. Popliteal vessels exposed in posterior wound. External popliteal nerve cut. Röntgenogram shows transverse fracture of femur just above condyles with comminution of external condyle. *Operation.*—Débridement of posterior wound. Nerve sutured. U-shaped incision anteriorly. Fluid and blood-clot evacuated. Bony fragments of external condyle removed. Joint closed anteriorly except for short opening which included wound of exit. Posterior wound left wide open. Thomas splint. *After-treatment.*—On fifth day after operation delayed primary suture of posterior wound. Evacuated in good condition on the seventh day.

CASE XII.—*Exception to the rule that an open synovia connotes*

movement. Penetrating shell wound, outer side of knee-joint. External tuberosity destroyed. External popliteal nerve severed. Three hours old. Smear shows diplococcus. *Operation.*—U-shaped incision. Débridement of track. Shell fragment removed together with the greater part of the external tuberosity. Edge of patella rongeured. Popliteal nerve resutured and buried in muscle. Patellar tendon resutured. Inner side of incision resutured. Outer side left wide open. Cabot splint. *After-treatment.*—Patient discharged from hospital two days later in good condition.

CASE XIII.—*Effect of early excessive movement in joint closed tightly.* Perforating bullet wound, inner side of knee-joint. Perforation of internal condyle, without fragmentation. Eight hours old. *Operation.*—Débridement of entrance and of exit wounds to bone. Escape of small amount of fluid from joint. All layers closed tightly. Cabot splint. *After-treatment.*—Immobilization continued for two days. Movement, evidently in excess, caused marked synovitis. Aspiration. Culture gave no growth. A further period of immobilization, followed by more gradual movement, procured better results. Discharged from hospital ten days after operation in good condition.

SUPPURATING CYST OF THE URACHUS, WITH CONCRETION

BY WILLIAM G. WARD, M.D.

OF EAST LYNN, MASS.

THE patient was a woman, forty-four years of age, who, however, appeared to be fifty-four. She had been working as a stitcher the past year in a factory, making heavy duck sundries for use in army accoutrements. She had always been a very active woman. Her past history was excellent. She had not passed the menopause. Her present illness was thought to run back some eight weeks. She first consulted a physician about two weeks before I saw her, because of pain and discomfort in and around the navel. This pain was intermittent in character at first, later becoming almost continuous, causing her to walk bent forward. She lost her appetite at the time; became emaciated; had "chills and fever"; did not sleep very well.

On examining the patient I found her to be a very thin and wrinkled, highly nervous type, middle-aged woman. She had a dry, coated tongue. Skin sallow, conjunctivæ clear, and no jaundice. Heart and lungs negative. For the last ten years she had had considerable discomfort from moisture in the umbilicus, which at times was very offensive, smelling like urine. She had to wear a cloth pad over the navel all that time, and every day had to cleanse the parts to prevent irritation.

At this time she is unable to walk upright on account of the pain and swelling in her navel. She says her sleep is now broken by severe contracting pains in the umbilical region. She has become very much depressed, mentally, and has no inclination for food.

On examining the abdomen, I found a tumor mass, round in shape, about the size of an orange, which was just below the navel, and apparently in direct contact with its lower border. The umbilical wall is obviously somewhat elevated and reddened. The floor of the umbilicus is bathed in a thin, watery pus, and an odor of urine is present. The tumor mass feels hard and brawny, and is slightly movable sidewise, with apparent fluctuation. The skin over this tumor shows some slight redness and inflammation. There are no signs of any abdominal complications. There is no swelling of the inguinal glands. Her menstrual periods are still normal. The kidneys are normal. She has had no miscarriages. There is no specific history.

November 20, 1918, a median incision was made from the edge of the umbilicus to the pubis. The abdominal wall being very thin, I expected to enter the cyst easily, but was surprised at its density. The walls of the cyst, as I cut through, had a fibrous, rough, gritty feel. On entering the cyst cavity, about eight ounces of a yellowish, very fetid pus exuded. At the umbilical end of the cyst, I found and evacuated an oval-shaped mass, in consistency strikingly like fine yellow cornmeal. This mass was about one and a half inches long and three-

quarters of an inch wide, and about one-half inch thick. The removal of this oval mass disclosed a very small aperture, opening directly on to the floor of the umbilicus. This opening would admit the point of a fine probe. The cyst cavity would measure about three inches long by two inches wide, and its walls were remarkably smooth without any roughness in any of its parts. The cyst was closely adherent both to peritoneum and fascia, and I did not attempt to dissect it out. The urachal opening I did not attempt to tie, on account of the tenacity of the surrounding tissue. I simply swabbed out the cavity with tincture of iodine, and packed with iodoform gauze. The patient began to improve in health almost immediately; the wound healed rapidly from the bottom, so that in about ten days no more dressing was needed, and in two weeks she was discharged with a firm scar. I noticed, with surprise, how quickly the thick fibrous wall of the cyst disappeared. I should say all the thickness apparently melted away in about four or five days.

The oval mass had acted as a sort of a ball-cock; when it moved it would allow a small amount of urine or pus to flow into the umbilicus through the tiny opening. For several years, the patient told me, she had frequent desire to urinate, but as soon as the abscess formation began this desire had ceased and urination became normal.

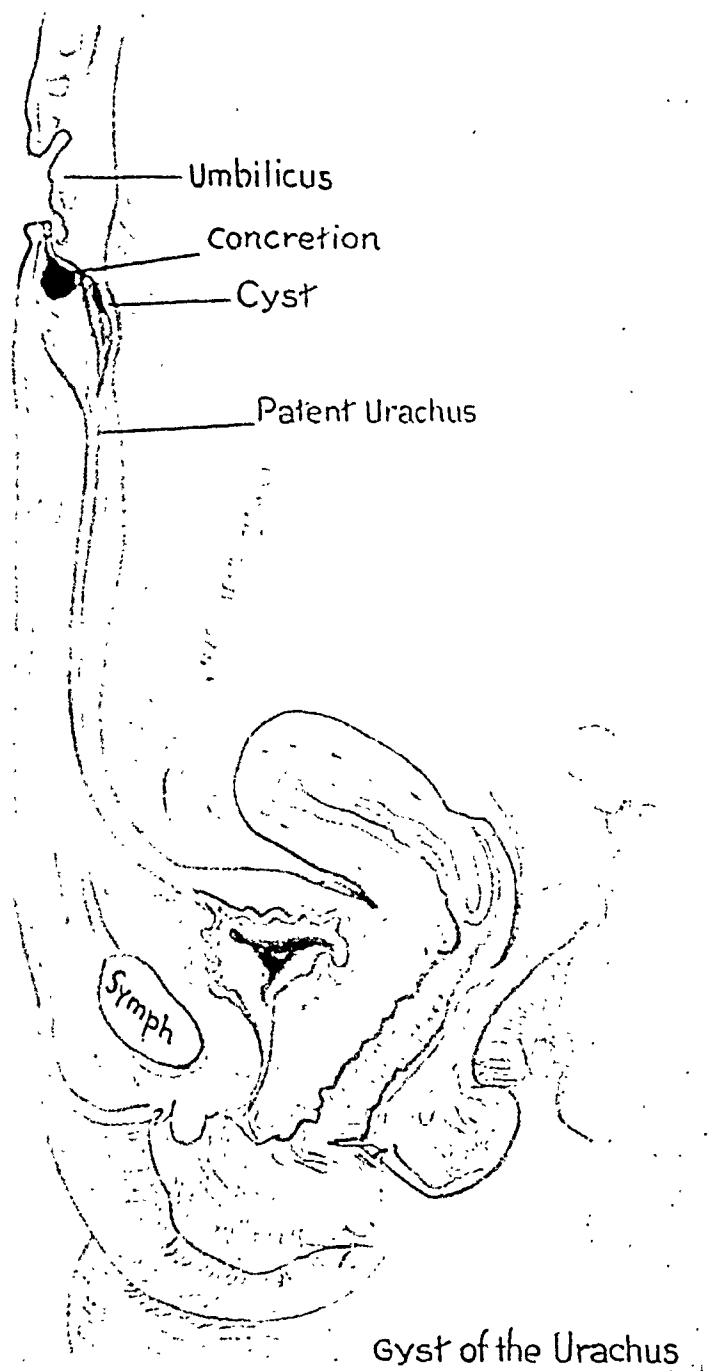


FIG. 1

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

Stated Meeting, held January 8, 1919

DR. CHARLES N. DOWD in the Chair

PERINEAL PROSTATECTOMY

DR. PARKER SYMS showed four consecutive cases of perineal prostatectomy to illustrate results obtainable by this method. The patients all showed great improvement in general health. The surgical results were most satisfactory. All these patients have fully restored bladder function. Each one had full bladder control a few days after operation.

They varied in age from fifty-two years to over seventy. They varied in condition from fair general health, to the greatest debility. Two of them were good surgical risks. Two of them were poor surgical risks. One of them was such a poor surgical risk that he did not give him a general anæsthetic, but used novocain locally. They all had retention, and all used catheters. The drainage tube was removed within twenty-four hours in each case. They all had bladder control within a few days from the operation. They were all essentially well within two weeks, but their wounds were still healing. They all went home within three or four weeks. One man went home on the fifth day. As a late result they are all wonderfully improved in health, and they all have perfectly restored bladder function. The first patient exhibited was able to leave the hospital soon after operation. He had full bladder control when the operation was finished. On the third day after operation, he held his urine 12 hours, and then voided voluntarily.

CASE I.—J. M. S., a merchant, aged sixty-eight years, consulted Doctor Syms, March 19, 1918. At that time patient had complete retention of urine. He was being catheterized every six hours. He gave a history of having had frequency and retardation for a considerable time. He had a sudden attack of retention March 10, 1918. At that time, he had 4 quarts of urine drawn with a catheter. When examined by Doctor Syms he was a pale, thin, sickly individual. His general condition was poor. Rectal examination showed an enlarged prostate. The right lobe being noticeably larger than the left, and one could feel a middle lobe. Cystoscopic examination by Doctor Lowsley revealed large intruding lateral lobes with a well-marked sub-cervical lobe protruding into the bladder.

Operation (March 28, 1918).—The lateral and middle lobes were enucleated by the technic usually employed by Doctor Syms. There

was some difficulty in freeing the lobes from the neck of the bladder. However, this was satisfactorily accomplished. A single drainage tube was introduced, and it was evident the patient had retained his bladder control. The prostatic spaces were packed, and the patient returned to his bed. Drainage tube was removed in twenty-four hours. Patient showed bladder control after tube was removed. Patient was sitting up out of bed within forty-eight hours.

On the third day the patient held his urine twelve hours and then voided it spontaneously. On the fifth day, the patient was able to be dressed and to go home. From that time on, he was able to be up and about. His wound healed progressively.

Present condition: Patient is greatly improved in health. He has been able to resume his active business. He has completely restored bladder function, holding his urine four and five hours. Sometimes he urinates once during the night.

CASE II.—H. S., aged seventy years, admitted to Lebanon Hospital, November 4, 1918, with prostatic obstruction and complete retention of urine. The patient was in wretched physical condition. He had paralysis agitans, chronic bronchitis with emphysema, and a large inguinal hernia. He had chronic nephritis, with a marked kidney insufficiency. He showed marked evidence of advanced arteriosclerosis. He was considered to be a very poor surgical risk. A general anæsthetic was deemed too dangerous for him.

At operation, November 13, 1918; under local anæsthesia, both large lateral lobes were removed, also a fair-sized middle lobe. Drainage tube was removed within twenty-four hours. Patient showed bladder control by the third day. He urinated partly through the urethra by the end of the first week, holding his water one hour and a half by that time. Discharged from the hospital December 2, 1918 (less than three weeks).

Present Condition.—Patient is remarkably improved in general health. He has perfectly restored bladder function, being able to hold his urine and to empty his bladder without difficulty. His improvement is like a regeneration.

CASE III.—A. B., aged fifty-two years, was admitted to Lebanon Hospital November 11, 1918, on account of prostatic obstruction with complete retention. The symptoms of retardation and frequency had extended over a period of about three years. They increased until finally complete retention ensued, and he was dependent on systematic use of a catheter. The patient was a man of fairly good physical condition. His kidneys showed a fair degree of efficiency. He was apparently a good surgical risk. Examination showed an enlarged prostate with complete retention.

At operation, November 13, 1918, at Lebanon Hospital, perineal enucleation of the lobes was accomplished without difficulty. The exposition was very satisfactory, so that the proceedings could be plainly seen and demonstrated. A large peduncleated middle lobe was delivered through the bladder orifice, and brought into view and then removed. The tube was removed within twenty-four hours. The patient was out of bed within twenty-four hours. The patient showed

PERINEAL PROSTATECTOMY

bladder control, keeping dry for an hour, within five days. He urinated through the urethra on the eighth day. He was discharged cured on December 6th (about three weeks).

Present Condition.—The patient is in good health. He has perfect bladder function. Controls his urine and empties his bladder voluntarily.

CASE IV.—L. S., aged sixty-three years, was admitted to Lebanon Hospital on December 2, 1918, with prostatic obstruction, causing complete retention, with overflow. This patient was a fair surgical risk. His general condition was fair. His kidneys were not badly damaged. Examination revealed a large prostate, with soft lateral lobes.

At operation, December 4, 1918, the lateral lobes were satisfactorily enucleated through the perineum. The proceedings could be plainly demonstrated and seen. There was a pedunculated middle lobe within the bladder, which acted like a ball valve. This was delivered through the bladder orifice, and removed as in the case above. The tube was removed within twenty-four hours. The patient was out of bed within twenty-four hours. He had bladder control, keeping dry about an hour at a time, by the seventh day. He urinated through the urethra by the tenth day. The patient was discharged completely cured on December 30th (four weeks).

Present Condition.—The patient is in good health. He has fully restored bladder function, holding his urine several hours, voiding voluntarily, and in fact, is free from symptoms.

In answer to a question as to what the sexual powers of these men were, Doctor Syms said that he was unable to state off-hand. He further said that this is a very difficult question to answer, because the evidence is usually unsatisfactory. We have to depend for the most part on unreliable hearsay evidence. Where he has gone into this matter in a series of cases, he has been convinced that perineal prostatectomy restores lost sexual function in some cases where it had been absent, and that this function has been doubtless lost in some cases where it had been present before operation. He considered this matter to be one of secondary importance in that class of cases. He believes prostatectomy is performed almost entirely as a life-saving measure. It is really a case of life and death with these patients.

In answer to a question whether after operations by the perineal route a larger percentage of men lose power of control over urination than after operations by the suprapubic route, Doctor Syms stated that he could only answer this in a general way: That his experience had been that the bladder function is restored in the vast majority of cases. He had had only 4 or 5 cases where there had been decided loss of control by the bladder sphincter. If the bladder sphincter is intact after the operation, the patient will have control. One of the patients presented to-night held his urine twelve hours on the third day. At the time of operation, the bladder sphincter closed upon the tube, and there was no leakage around the tube. If the operation is properly and successfully performed, removing nothing but the prostate from the fascial sheath, and not removing prolongation of the sheath, the

sphincter muscle will not be interfered with. If this is so the patient will have full control, and we will have a satisfactory result. By a satisfactory result, he means that the patient is able to hold his urine, and to empty his bladder without difficulty. In other words, he has restored bladder function.

DR. CHAS. N. DOWD said, concerning the control of urine, that in the last case of perineal prostatectomy done by him, it was apparently particularly successful while the man was still in the hospital. He was passing urine through the urethra within ten days; but he afterward came back complaining of incontinence. The operation had been done by the Young method and was done with much care in separating the prostate from its sheath, and still he had this lack of control which was presumably due to the interference with the nerve supply.

DR. ROBERT T. MORRIS stated that he had begun with the perineal prostatectomy and had done most of his work that way until he tried the suprapubic for some cases. Now he almost never uses the perineal route. Concerning sexual power he stated that some patients have lost power which they had before the operation and some have regained it having lost it before operation.

ANEURISM OF THE TEMPORAL ARTERY

DR. CHARLES A. ELSBERG presented a young man, who had been injured in March, 1918, while working in a dental laboratory. He was struck by a little splinter and noticed a drop of blood in the temporal region. After two weeks he began to notice a throbbing on the right side of his head and soon noticed slight enlargement in his temporal region. In April he had a large pulsating mass in this region. Compression of the external carotid artery stopped the pulsation and stopped the sound in his head. The swelling was chiefly in front of the ear. In April the external carotid artery was tied, the swelling became very much less and the throbbing sound disappeared for a time. But it has now returned together with the swelling in the temporal region, which is of the size now seen and with marked pulsation. Whence is the blood supply? Should an effort be made to extirpate the entire mass?

DR. ROBERT T. MORRIS suggested making a clean cut and removing the aneurismal tumor *in toto*. A great many increased anastomoses with the temporal artery take place when the external carotid is tied. He suggested that this excision be done without interference with the many of the branches of the facial nerve, cutting below and in front of the hair line.

RESECTION OF SUPERIOR MAXILLA WITH PRESERVATION OF HARD PALATE

DR. JOHN DOUGLAS presented a girl, fourteen years of age. She noticed a growth in right nostril four months previously, which had greatly increased in size until the time of admission to the hospital. It was then about five by three centimetres in diameter and completely filled the right side of the nose, deflecting the septum to the left and completely filling the nasal cavity,

RESECTION OF ULNA FOR OSTEOMYELITIS

protruding from the right nostril and projecting into the nasopharynx posteriorly. The Wassermann was negative.

On August 13th the growth was separated from the nasal cavity, drawn out in pieces and the nasal cavity well cleaned; when it was found that the growth had taken origin in and projected from the antrum. A frozen section was made from this tumor which proved to be an osteosarcoma. No giant cells were present. Two days later a resection of the superior maxilla was performed in the typical manner, with the exception that, instead of making the usual median incision through the hard palate in the median line, the mucous membrane along the alveolar border of the jaw was divided and the mucous membrane and periosteum separated from the hard palate. An incision was then made through the bone in the median line and the superior maxilla removed in the ordinary way, the flap of periosteum and hard palate being then sutured to the divided edge of the mucous membrane of the cheek with the exception that at the posterior angle, where the hard and soft palate joined, an opening was left for drainage. Through this opening packing was inserted into the space left by the resection of the superior maxilla, thus leaving most of the roof of the mouth in place instead of having the oral cavity continuous with that of the nasal as is usual after a resection of the superior maxilla. This was deemed safe in this case as the growth, while taking its origin from the antrum, did not seem to involve the bone. Before doing the resection an incision was made in the neck and the glands excised and the external carotid artery ligated.

A further microscopical examination of the section removed showed tumor tissue of the same type as previously described, involving the antrum but not involving the bone, although distinct fragments of well-formed bone containing growing bone cells surrounded by a layer of osteoblasts was scattered through the tumor tissue. As before no giant cells were found.

The drainage opening has contracted and become smaller and patient now wears a plate with comfort, and the result is obviously better than if the large portion of the roof of the mouth had been removed, and while this may not be a safe procedure in a number of cases, as when the bone is involved in carcinoma, in this case the results justify the means employed.

RESECTION OF ULNA FOR OSTEOMYELITIS

DR. JOHN DOUGLAS presented a man, fifty-nine years of age, who, seven weeks previous to his admission, fell to the sidewalk and injured his right arm; five days later pain and swelling caused him to enter the hospital for treatment, the diagnosis at this time being infected hematoma of the right wrist. After this he was treated for two weeks in the Out Patient Department, when an X-ray showed osteomyelitis of the lower end of the ulna, he was then operated on in the hospital, the medulla opened, a sequestrum removed and the medullary cavity lightly curetted and the wound drained. The wound failed to heal and he was readmitted to the hospital on January 18, 1918 (the previous admission having been in October, 1917). At this time

his X-ray showed the bone markedly thick and riddled along its whole shaft with numerous cloacæ. There was a small discharging sinus about midway down the forearm and an old scar of the former operation running down the ulnar surface of the forearm. The small and ring fingers were partially contracted and there was poor flexion in these two fingers. The ulna itself was involved from about one and one-half inches from the upper portion to about two inches from the lower end, the bone was moth eaten and there were five separate cloacæ. A linear incision was made over the former scar along the ulnar surface of the right arm; the periosteum was elevated with a periosteal elevator from the surface of the ulna, it was excised with a Gigli saw at a point one and one-half inches from the upper end and about two inches from the lower end; iodoform gauze was then placed in both ends of the incision and the fascia and skin closed over with interrupted plain sutures, leaving the iodoform gauze as drainage. An anterior basswood splint was applied. There was a large amount of swelling and redness around the wound, evidently due to iodoform poisoning immediately after operation. This disappeared after a few days, but on February 17th, twenty-nine days after operation, he developed erysipelas and was transferred to another hospital. This, however, did not prevent his wound healing, and he returned shortly afterwards with the wound entirely healed.

A few weeks later he returned to his previous occupation of marble cutter in which occupation he used a mallet with the operated arm all day, with little or no pain, and very little disturbance of function.

It was of interest to follow in the series of X-rays the result of this subperiosteal resection. There was no attempt to form a new shaft to the bone. There was a very small amount of growth in the form of a spur from the lower fragment of the *ulna* remaining. From the upper end of the ulna fragment there has been a most curious growth of bone, which started down from the divided upper part of the ulna and then has apparently turned at right angles and now appears to abut against the radius with which it has formed a false joint and is apparently of use in functioning and assisting in the support of the radius and in pronation and supination of the forearm. The erysipelas, which developed about the twenty-ninth day, cleared up in about two weeks, and the patient was back at work six weeks to two months after the operation.

REMOVAL OF ENCHONDROMA FROM FIBULA—BONE GRAFT

DR. JOHN DOUGLAS presented a woman thirty years of age, who noticed a swelling just above the left ankle one year before admission. It had changed very little in size since she first noticed it, and there was not much pain unless the patient received a blow over the ankle. Other history negative. Examination showed a marked thickening of the lower end of the fibula just above the ankle which appeared to be caused by some central growth of the bone, causing a symmetrical enlargement. X-ray showed what was apparently a bone cyst.

UNUNITED FRACTURE OF LEG—BONE GRAFT

An incision was made lateral to the tumor, the skin flap turned back, the bone opened with chisel, and the cavity which was curetted out was filled with a firm tumor of gelatinous consistency. As the removal of the enchondroma, as it proved to be on microscopical examination, would have left such a cavity that it would have filled with difficulty, and as the outer wall of the tibia was removed, and this would have left the bone weak with a subsequent fracture probable, a bone graft was employed. The bone graft was cut from the upper end of the tibia, on the same side, in such a manner as to fit into the cavity; this was placed in the cavity and the wound closed; the subsequent history was uneventful.

A series of X-rays taken over a period of six months shows in a very interesting manner the growth of the graft to the bone at both ends, and the continued density of the graft would seem to indicate its continued viability and its union with the living bone at both ends, rather than its replacement by new bone.

UNUNITED FRACTURE OF LEG—BONE GRAFT

DR. JOHN DOUGLAS presented a man thirty-two years of age who was struck by an automobile and thrown against a tree and his leg fractured four months before being seen by him. The fracture had been reduced and a plaster case applied at another hospital. After nine weeks it had not united, whereupon another case was applied, and he was recommended to walk with the support of this case. There was no venereal history and the Wassermann was negative.

An X-ray taken at the time he came under the care of Doctor Douglas showed a fracture of the upper third of the tibia in rather bad position, and two fractures of the fibula, one in the upper third, the other in the middle third, with no sign of apparent union at any site of fracture. A longer case was applied and he was given advice to wait two months. On February 8th he reentered the hospital with his leg in practically the same condition and an X-ray at this time showed no apparent attempt at union. On February 13th, six months after his fracture, an incision was made on a level with the site of the fracture, the fibrous union was broken up and the overriding and marked displacement corrected as well as possible. With an Albee saw a fragment of bone about five inches in length was removed, about two-thirds of which was taken from the portion of the tibia below the fracture line, the rest from the upper portion; this fragment was replaced in the gutter in a reversed position and fastened in place with kangaroo tendon passed through drill holes on each side of the gutter, thus giving firm implantation of the graft. The case was then reapplied.

A series of radiographs taken at various periods afterwards repeatedly shows the progress of the osteogenesis which resulted after the insertion of the graft, with the firm union which has finally resulted. It is of particular interest to note the continued density, at all times, of this graft in the series of pictures taken at various times.

NEW YORK SURGICAL SOCIETY

The X-ray taken in April shows marked density of the graft, there apparently having been no absorption. The X-ray taken in May show new bone beginning to form in the fibula. Fifteen months after the fracture and eight months after the operation there is good union, the lateral X-ray at this time shows the graft united and new bone from the end of the graft down to the bottom of the gutter and one space where there is rarefaction or absence of deposit of salts.

FASCIA LATA GRAFT FOR CRANIAL DEFECT

DR. JOHN DOUGLAS made a report on a patient he had presented before the Society about two years ago. The patient was a young man on whom he had operated for Jacksonian epilepsy, due to a compound fracture of the skull; on account of the adhesions between the cortex of the brain and the dura he had dissected out the adherent portion of the dura and replaced it by a flap of fascia lata to which the fat was attached; this was inserted with the fat side adjacent to the cortex. At the time of presentation of the case the permanence of the cure was questioned. The patient has since then entered the army, been with the A. E. F. in France and been promoted to the position of corporal, and Doctor Douglas read a letter from him stating that he had no further convulsions since his operation.

INJURY OF MUSCULOSPIRAL NERVE

DR. ROBERT T. MORRIS presented a young man, twenty-five years of age, with paralysis of the musculospiral nerve. The man was injured on September 24th, and had a comminuted fracture of the humerus. An operation was done on the same day with removal of some of the fragments. There is now wrist-drop and paralysis of the musculospiral nerve. In the subsequent operation done by Doctor Morris for musculospiral involvement, he exposed the musculospiral nerve through a long incision and found that the nerve for three inches was about one-fourth the entire thickness of the nerve above and below, due to crushing and subsequent constriction by connective tissue. The question arose, should he graft three or four inches of the internal saphenous nerve or should he dissect out this partly good nerve and wrap it in fat or muscle to prevent further compression by the connective tissue. This he had done. The question arose was this the best to be done in this case or are we to look forward to the necessity of grafting the nerve, and the speaker said he would like to have the opinion of the surgeons here upon this point.

Doctor Morris showed an ingenious support for the patient's forearm devised by the patient himself.

DR. ALFRED S. TAYLOR reported on a case he had of fracture of the humerus which failed to unite, accompanied by paralysis of the musculospiral nerve. The patient had had a fracture of the humerus, due to accident at an army camp. A plaster case had been applied for four weeks and there was no union. Subsequent to this two operative attempts were made to obtain union

INJURY OF MUSCULOSPIRAL NERVE

of the bone, and following the second operation there was complete paralysis of the musculospiral nerve. This had persisted for about five months when he came under the care of Doctor Taylor. There was total loss of power in the musculospiral, and there had been no form of supporting apparatus used to prevent overstretching of the paralyzed muscles. There was a scar extending along the external border of the right upper arm from the shoulder nearly to the elbow. At operation for repair of the musculospiral nerve that old scar was excised, and proved to be very thick and dense. The musculospiral nerve was exposed in the intermuscular space between supinator longus and brachialis anticus, and was then followed upward. It very soon entered the dense scar just mentioned. It was followed upward carefully, and at no place had been divided at the time of second operation. It was surrounded by dense scar tissue for a distance of 10 cm., starting at a point about 4 cm. above the external epicondyle. Above and below the cicatricial constriction the nerve was congested and somewhat swollen. Its sheath along the cicatricial area was very greatly thickened and the nerve itself correspondingly constricted. When the thickened sheath was split longitudinally it rolled outward, almost like an elastic material, and exposed the musculospiral nerve itself, very much diminished in calibre from the compression, but otherwise without obvious damage. The thickened nerve sheath was dissected away from it throughout its whole length, and then a strip of fat was secured from the same patient and fastened around the nerve by catgut sutures, so as to make a fatty sheath. The wound was then closed, the patient made a good recovery, and got a primary union. The forearm and hand were put on a support, so as to relax the extensor muscles.

About two weeks after his operation he was started on massage, electricity and hydrotherapy, and began immediately to show some evidences of returning power in the musculospiral nerve. The improvement was somewhat slow in rate, but was steady, and when last seen a few months ago he had recovered a very considerable degree of power in the muscles supplied by his musculospiral, and will undoubtedly go on to a complete recovery. Meanwhile the fracture in the humerus has failed to unite, so that a further attempt at correction of the trouble with the bone will be necessary.

DR. NATHAN W. GREEN mentioned a case of his of delayed union in fracture of the humerus with paralysis of the musculospiral nerve. This patient had regained function after dissecting out and transplanting the nerve. The incision made was a curvilinear incision starting in front of the bend of the elbow and passing outward over the fascial septum between the supinator longus and the biceps and the brachialis anticus.

This allowed the exposure of the lower part of the nerve which was of good size and was easily followed up through the cicatricial tissue in the neighborhood of the fracture. The nerve was then dissected out of the cicatricial tissue for about two inches, when it was lifted out of its bed and easily transplanted.

His recollection was that the portion of the nerve above and below the

imprisoned portion was of normal size, but the latter portion showed evidence of compression.

DR. JAMES M. HITZROT reported a case operated on about fourteen months ago for ununited fracture of the humerus with the musculospiral nerve caught in the callus and with loss of function in the nerve distal to the fracture. The nerve was compressed, being larger above and below than at the site of compression. A bone graft was used for the non-union and the nerve was surrounded with fat and fascia taken from the thigh. The patient developed function in the nerve some four months after operation, and developed complete function of the arm in about eight months. In October, eleven months after the operation, while carrying something, he slipped and fell, the arm was twisted under him and he refractured the arm at the point of previous non-union. The X-ray showed what was apparently fibrous tissue or cartilage on either side of the fracture. At the second operation, the bone had broken exactly in the same place as the previous fracture. The bone graft evidently had been maintaining the stability of the bone across the line of fracture, as there was no evidence of regeneration from the two ends of the humerus, and the refracture evidently broke the graft which while living bone had not been strong enough to withstand the strain put upon it by the above-mentioned fall. The nerve, which had completely regenerated insofar as function was concerned, was apparently the same size throughout the distance of its exposure, and in the region of its previous compression was free from adhesions and apparently quite normal in appearance.

NOTES ON RUBBER GLOVES

DR. ROBERT T. MORRIS read a paper with the above title for which see page 52.

DR. PARKER SYMS said that it is very important that a paper of this sort should be so worded that it could not be used to make trouble from a medico-legal standpoint.

Failure to wear rubber gloves does not constitute negligence. He instanced the fact that one of the most successful and reputed surgeons of Great Britain operates without gloves, and his successful work fully justifies him in that practice.

DR. CHARLES N. DOWD said that when bacteriological tests of articles in the operating room are made it is well to have the rubber gloves included. There are two common ways of sterilizing rubber gloves, one by boiling and the other by steam. A third way, by the use of chemicals, is not now in common use. It is well as a matter of ordinary routine to take tests of the operating room and to pay attention to these points.

If the method of boiling is used, care should be taken that the gloves are entirely immersed. If a part of the glove floats above the boiling solution, it is manifest that that part is not properly sterilized. It is subjected to a moderate degree of moist heat but not to boiling solution.

If steam sterilization is used rubber surfaces should not be in apposition,

NOTES ON RUBBER GLOVES

for the steam cannot get access to such surfaces and they, therefore, are only subjected to dry heat which has far less sterilizing power than compressed steam.

One other point, and that is the question of puncture. If the glove is punctured there is always a possibility of infection through the puncture. If punctures occur they usually come through the end of the first finger. This occurrence may be largely safeguarded by having finger cots sterilized with the gloves and slipped over the index fingers before the gloves are put on, thus making an extra barrier against infection.

DR. NATHAN W. GREEN said that it was conceivable that the season of the year might have some bearing on the question of gloves. In the very warm season of the year when one is sweating and working hard the hands will be found to be bathed in perspiration inside the rubber gloves; in the cold season of the year when one takes off the gloves after operating the hands will be found dry. Now, if the operator is sweating and the hands are bathed in perspiration inside the rubber gloves, when a puncture occurred, the sweat would be extruded through the puncture and might contaminate the wound more than if the gloves had not been worn.

He said he had made it a practice, where particularly anxious not to run the risk of any contamination, to iodine his gloves. Occasionally after removing the gloves a spot of iodine on the index finger was found where a puncture had been overlooked.

DOCTOR SYMS further stated that, where he had worked in casualty clearing stations, the surgeons used one pair of gloves in operating on case after case, washing the gloved hand with soap and water between operations. In those circumstances it would have been impracticable to change gloves. This method seemed to work very well. The washing of the gloved hand seemed quite as satisfactory as washing the bare hand.

BOOK REVIEWS

NEOPLASTIC DISEASES. A Text-book on Tumors. By JAMES EWING, M.D., Sc.D., Professor of Pathology at Cornell University Medical College, New York City. Octavo of 1027 pages with 479 illustrations. Philadelphia and London, W. B. Saunders Co., 1919.

Neoplastic disease is wrapped up in the history of medicine. Cancer is discussed in the oldest literature of India and Persia. It is mentioned in the Papyrus Ebers (B. C. 1500). The ancients treated it by excision and by escharotics. Hippocrates transmitted a considerable mass of descriptions of tumors. The belief in the humoral origin of these diseases subverted the possibility of anatomic study. An early appreciation of anatomic malignancy is found in Leonides of Alexandria (A. D. 180) who dissected out cancer of the breast with the knife and cautery, cutting in healthy tissue beyond the disease, much the same as is done to-day.

Ewing states that, during the twelfth to the fifteenth centuries the ban of the church fell not only upon dissections of the dead body but upon the practice of surgery also, which could be studied only in private and practised only by nomads, while the monks gave themselves over to translations of Galen's writings and speculations in alchemy, astrology, and magic.

Then during the Renaissance, Fabricius (sixteenth century) differentiated between inflammatory swelling and neoplasm. And so gradually the scientific knowledge of tumors began. This knowledge became formulated upon an anatomic basis when the microscope came into use. Clinical classifications then were superseded. With the development of the achromatic microscope the study of tumors entered a new era.

Although careful histologic studies were made, the pathologists of the middle of the nineteenth century believed that cancer originated from the fluid of the blood. This was Virchow's primary conception. It was believed that the disease was an organized exudate from the blood with overnutrition. When Virchow enunciated his cellular hypothesis, that all cells spring from cells, the continuity of growth of tumors became better understood.

In this work Ewing presents the main features of the origin, structure and natural history of neoplasms. The idea has been held up until very recent time that tumors fall into a limited number of classes and that these classes are not appreciably modified by the different organs in which they occur. Under this conception it was assumed that all fibromas, sarcomas, or cancers, no matter in what organ found, were constant to their type, and accordingly a constant causative agent could be assumed.

BOOK REVIEWS

Ewing presents tumors as specific diseases in which there are many variations. While the past has been much occupied with the classification and the histogenesis of tumors, the indications are that the twentieth century will be characterized by experimental study of the etiology of tumors, and consequently new knowledge which may be applied to prevention and treatment.

This work discusses the classifications of tumors, the nature of metastasis, the chemistry of tumors, theories of the nature of cancer, special etiological factors, and parasitic theory, and experimental cancer research. It is shown that the greater the variation in type between a tumor and the structure in which it originates the more malignant is the tumor. This is the principle worked out by Hansemann. To illustrate the variations in growth caused by variations in the amount and character of nourishment the author invokes the experiments of Jacques Loeb. These experiments show that a certain leaf when cut into segments fails to develop shoots so long as it remains attached to its stem, but when severed from its stem it puts out a new growth from each segment. This phenomenon is supposed to depend upon the flow of nutriment which ceases to pass from the leaf when the normal channel is destroyed and proceeds to express itself in new outshoots.

The parasitic theory of the etiology of cancer is given the space it deserves. The reviewer recalls well the heated discussion about 1895 on this subject. He recalls how severely he was castigated for his heterodoxy expressed in a paper on "Some Fallacies Inherent in the Parasitic Theory of the Etiology of Carcinoma" (*ANNALS OF SURGERY*, vol. 17, 1893), and again in a paper entitled "Are the Parasitic Theories of the Etiology of Carcinoma Tenable?" (1893). Now Ewing says: "The parasitic theory reached the height of its popularity as a scientific theory about 1895, but during the last fifteen years it has rapidly lost ground, and to-day few competent observers consider it as a possible explanation of the unknown element in blastomatosiis."

The larger part of this book is given to special oncology. Each tumor class is considered. Tumors of special tissues and structures are fully discussed. In the thyroid, epithelial overgrowth is recognized in three forms: (1) simple goitre, (2) Graves' disease, and (3) true tumors. Tumors of the pituitary body are classified as (1) diffuse hyperplasia and focal adenoma, (2) adenocarcinoma, and (3) malignant atypical carcinoma. True tumors of this organ are so uncommon that many of the recorded cases must be regarded as simple hyperplasia. The relations of these diseases to infantilism, giantism, and acromegaly are described. A final chapter deals with teratology.

This book is provided with a full and well-arranged bibliography. It

BOOK REVIEWS

brings the subject of tumors up to date. It is a valuable text-book. The illustrations are largely from photographs. They are well made and truly illustrative.

The work represents a vast labor on the part of the author. It is of value to the student as a guide from an authoritative source; and to the practitioner of medicine and surgery it makes available an understanding of a field too little studied by either.

JAMES PETER WARBASSE.

MANUSCRIPT FROM ARMY MEDICAL OFFICERS

As stated in the circular memoranda for Editors of Medical Publications issued by the Surgeon General's Office on March 27th and May 22, 1918, it is required by paragraph 423; Manual of the Medical Department, that all medical manuscripts by medical officers, U. S. Army, intended for publication shall be first submitted to the Surgeon General's Office, Washington, D. C., for approval. This regulation, which has been very courteously complied with, to date, is still in force as far as medical officers on active duty are concerned. In the case of medical officers recently retired from active duty, it is requested, as a courtesy to the Surgeon General and in aid of assembling material for the Medical History of the War, that all medical manuscripts based upon military or official records or upon military experience during the war, be submitted as heretofore, to the Secretary, Board of Publications, Surgeon General's Office, Washington, D. C., for record and approval and that such MSS. be accompanied by a carbon copy. Upon approval, the original copy will be forwarded to the journal designated, for publication, and the carbon copy will be filed in the records of the Medical History of the War.

For the Surgeon General:

(Signed) C. R. DARNALL,
Colonel, Medical Corps, U.S.A.,
Executive Officer.

WAR DEPARTMENT,
Office of the Surgeon General,
Army Medical Museum and Library,
Washington, March 20, 1919.

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BONE TUMORS. CENTRAL (MEDULLARY) GIANT-CELL TUMOR (SARCOMA) OF LOWER END OF ULNA, WITH EVIDENCE THAT COMPLETE DESTRUCTION OF THE BONY SHELL OR PERFORATION OF THE BONY SHELL IS NOT A SIGN OF INCREASED MALIGNANCY *

BY JOSEPH COLT BLOODGOOD, M.D.
OF BALTIMORE

A RECENT observation of this type of tumor involving the lower end of the ulna in which the bony shell was completely destroyed led to a reinvestigation of 47 cases of giant-cell tumor with especial reference to destruction of the bony shell or its perforation with infiltration of the surrounding soft parts.

This restudy has demonstrated that the complete destruction of the bony shell or its perforation at one or more spots with infiltration of the giant-cell tumor tissue has not been associated with any difference in malignancy.

The ultimate results in these 47 cases are almost all known at the present writing, and there have been no deaths from metastasis.

When the X-ray shows complete destruction of the bony shell, or when at operation the surgeon finds perforation of the capsule, the operator without this evidence will be inclined to do a more extensive operation—either an amputation or a more extensive resection which might interfere with the function of the limb.

The majority of these 47 cases of giant-cell tumor have come under the observation of a number of surgeons and pathologists, and from my correspondence with them, I am impelled to the conclusion that quite a number still consider this giant-cell tumor a *sarcoma*, and usually act on this conception and remove more than is necessary.

Distribution of the Central Giant-cell Tumor in the Forty-seven Cases Recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital.—Radius, lower end, 13; tibia, 11; femur, 10; fibula and ulna, 3; astragalus and os calcis, 2; ilium, clavicle, phalanx of toe, each 1; humerus, none.

This does not include the giant-cell tumor of the upper and lower jaws.

* This article is a continuation of two others which have appeared in the ANNALS OF SURGERY, August, 1910, vol. lii, p. 145, and August, 1912, vol. lvi, p. 210.

This seems to suggest that the giant-cell tumor arises most frequently in the lower end of the femur, the upper end of the tibia, and the lower end of the radius—portions of bones of the skeleton subjected to the greatest trauma.

The first case to be reported in detail is of interest, because the local growth at the lower end of the ulna had the compressibility and softness of a cellular sarcoma. The X-ray showed complete destruction of the bony shell. The next point of interest which is rather unusual in the giant-cell tumor, was the fact that this tumor was so filled with spaces containing blood that it resembled a cavernous angioma.

Pathological Report (No. 23852).—Giant-cell tumor of lower end of ulna. Operation: Resection with secondary bone transplantation. (Figs. 1 to 19).

This patient (E. C.), a colored girl, aged twenty-six, was referred to me by Dr. Emory Marvel of Atlantic City.

The patient's attention was called to the ulnar portion of the right wrist by a painless swelling one year before operation. This swelling has increased rapidly in the past three months. There has never been pain and practically no loss of function.

Trauma.—The majority of the 47 cases give a history of trauma before the onset of any definite signs of a bone lesion, but in this case and in a few others the history of a trauma could not be obtained. The patient's occupation was that of a housemaid. During the past three months, when the swelling became distinctly more rapid, she found that washing and ironing produced fatigue, but until a few days before operation she continued to do without discomfort all other general housework.

The patient had consulted physicians and had received only X-ray treatment, until she came under the observation of Doctor Marvel, who immediately advised surgical intervention.

Fig. 1 shows the clinical appearance of the swelling. There was no œdema of the skin, except over the top of the tumor, and here an area of skin about the size of a silver dollar was œdematous and on palpation gave a suggestion that the tumor tissue had infiltrated at least into the subcutaneous fat. At the pathological examination this proved to be incorrect. The subcutaneous fat was not involved, and *the operator could have saved more skin.*

The tumor itself seems circumscribed, but it is compressible and soft and gives the sensation of fluctuation. The ulna above the tumor can be palpated and the tumor arises from the ulna abruptly. There was no pulsation.

The clinical appearance of the tumor was therefore more suggestive of a malignant cellular sarcoma.

Figs. 2 and 3 are the X-rays taken by Doctor Marvel about two weeks before Fig. 4, the X-ray taken by Doctor Kahn at St. Agnes Hospital. All show almost complete destruction of the bony shell. In Doctor Marvel's plates as well as in the plate made by Doctor

BONE TUMORS

Kahn remains of the bony shell are present where the tumor expands abruptly from the shaft of the ulna, and here and there in all pictures remains of spicules of bone corresponding to the shell can be seen. In spite of this the shadow of the tumor is that of a circumscribed and not of an infiltrating local lesion. The radius and the carpal bones are not involved, nor does the ulna above the tumor nor any other bone show new periosteal bone formation.

From my experience with 13 cases of giant-cell tumor involving the lower end of the radius I knew from at least three cases that the bony shell could be completely destroyed without being associated with any increase in malignancy.

In this colored girl the blood was negative for Wassermann, the urine showed no Bence-Jones bodies, and the X-ray revealed no other bone lesion and no signs of metastasis to the lungs.

Diagnosis Based on History, Examination and X-ray.—From my experience with now more than 300 bone tumors I concluded that this tumor belonged to the giant-cell group. I had never observed a bone aneurism (malignant hemorrhagic bone cyst) in this situation.

In view of the fact that the extensor and flexor tendons, which in this case rested on the rapidly enlarging tumor, were not at all interfered with as to function, one could conclude almost positively that this tumor was still confined within a definite capsule, and that it could be resected without injury to the tendons. This proved to be correct.

Operation.—St. Agnes Hospital, January 4, 1919. The patient was anæsthetized with ether. No Esmarch was employed. Fig. 5 shows the beginning of the skin incision with the dissection of the flap and the removal of a fairly large area of œdematous and adherent skin.

Removal of the Skin.—Although I was quite confident that this was a giant-cell tumor, yet, when I came to operate, the fear of cutting into the tumor which is really not dangerous led me to remove more skin than was actually necessary. Fortunately sufficient was left to close the wound, but this removal of more skin than necessary complicated the secondary bone transplantation and has left a slight deformity in the sense of a narrow wrist. Had I cut into the skin I could have easily demonstrated that it and its subcutaneous fat were not infiltrated by the tumor. All of the flexor and extensor tendons could easily be separated from the capsule of the tumor, except the extensor carpi ulnaris and the extensor to the little finger. The former was divided on both sides of the tumor and no attempt was made to repair the defect. The remaining lower portion of the extensor to the little finger was sutured to the common extensor. (Function is now almost completely restored.) The ulnar vessels and the ulnar nerve were quite adherent to the capsule of the tumor. The vessels were ligated on both sides of the tumor. However, in dissecting the ulnar nerve from the capsule of the tumor, a little serum escaped. At this point the

capsule was thinnest. Immediately this portion of the tumor was covered with an alcohol sponge.

As the X-rays showed complete destruction of the lower end of the ulna, I felt that it was safer to remove the ulnar side of the lower end of the radius and to remove two carpal bones. This would not interfere with future function, and probably an attempt at disarticulation would have broken into the tumor at this point.

In removing the tumor the capsule was never injured and no fluid escaped, except when the ulnar nerve was dissected from the capsule.

Fig. 6 shows the method of preserving the ulnar nerve and the alcohol sponge over the slight perforation of the capsule.

Fig. 7 shows the method of removing the lower end of the radius and the carpal bones. Fig. 8 shows the stage of the operation when the tumor is held by an attachment to the lower portion of the extensor carpi ulnaris. Fig. 9 illustrates the closure of the wound without drainage. This also illustrates the narrowing of the wrist over the ulnar area due to the removal of too much skin. Fig. 10, an X-ray after operation, shows the ulnar defect.

This defect was repaired by the transplantation of a piece of the shaft of the tibia January 30, 1919, twenty-four days after resection.

Fig. 11 shows the transplant in place.

On February 20th, about three weeks after bone transplantation, all dressings were removed and the patient began to use the arm and hand with fair function.

Gross Pathology.—The ulna above the tumor, the distinct tumor capsule, the skin and subcutaneous fat removed with the tumor are shown in Fig. 12.

In the fresh, when I cut the tumor open it had a distinct capsule which varied in thickness from 1 to 5 mm. The cut surface of the tumor showed numerous cavities filled with blood not unlike a cavernous angioma. A few larger cavities contained clear serum unusual in angioma. Ramifying throughout the tumor were irregular areas of yellow, firm tissue not unlike fibrin, but there were no distinct firm whitish areas resembling the *ostitis fibrosa* in bone cysts which are now and then met with in the giant-cell tumor. Other portions of the tumor were red and spongy, more like a capillary angioma than the typical giant-cell tumor tissue. There was no infiltration of this vascular tissue beyond the capsule, but in the thicker portions of the capsule vascular areas could be made out between the fibrous strands of the capsule. The tumor was therefore present in the capsule, but had not perforated its outer layer. No bone could be seen or felt, except at one point when spicules were felt in cutting through the capsule near the ulna.

The surface of this tumor, after it had been in formalin a few days, is shown in Fig. 13, but it is not as characteristic as the surface appearance of the freshly cut tumor, nor the surface appearance (Fig. 14) of a photograph taken immediately after a fresh cut through the formalin specimen. In this picture (Fig. 14) we see the distinct capsule varying in thickness, the small and large blood cavities, the white irregular branching lines which in the fresh were yellow and suggested fibrin, and the spongy red areas. We can even make out in this picture the red areas in the thicker portions of the capsule.

The tumor, therefore, in its gross pathology differed from the ordinary giant-cell tumor chiefly in the presence of numerous small and large cavities filled with blood.

BONE TUMORS

Microscopic Pathology.—Fig. 15 (low power) pictures the capsule with giant-cell and vascular areas present between the fibrous tissue, but at no point in the microscopic section study does tumor tissue perforate the capsule.

The presence of blood in small and large cavities and intimately mixed with the giant-cell tumor tissue is shown in Fig. 16. The blood cavities, however, are not vessels, as they are not lined by endothelium, but represent hemorrhage into tumor tissue. The tumor itself is filled with small vessels of the capillary type, but the hemorrhage could have been from a larger artery entering the bone from the shaft or end.

In the tumor itself we see three typical areas: First, areas containing numerous giant cells (Fig. 17), areas with no giant cells, but differing only from the other areas in the absence of giant cells. (Fig. 18.) These cellular areas without giant cells and those containing giant cells might at first sight be looked upon as a mixed-celled sarcoma. But the pictures show that between the cells there are many fibroblasts and much eosin-staining connective tissue, much more than in the usual round-and-spindle-cell sarcoma. Many of the cells have the morphology of the endothelial cells, and many of the cellular areas suggest strongly endothelium-lined tubes of the capillary type. Some of the giant cells may be due to accumulations of proliferating endothelial cells; others, especially the larger ones, may represent the osteoclasts usually present in bone destruction. Fig. 19 taken from a yellow area in the gross specimen resembles organized fibrin.

From this study it is my conclusion that this tumor, in spite of its numerous areas without giant cells, belongs to the type of neoplasms that have been called in the literature giant-cell sarcoma, and for which I have suggested the term giant-cell tumor, until more is known of its etiology.

The more I study this group of local growths, the more convinced do I become that it belongs to a special type of angioma or granulation-tissue tumor of which the xanthoma is a variety.

The typical giant-cell tumors are observed on the alveolar border of the jaw and are usually called epulis. The etiological factor in this group seems to be granulation tissue from an infection about a tooth or its root cavity. The majority of tumors about the tendon sheaths contain giant cells and the stroma is not unlike the central giant-cell tumor of bone. These tendon-sheath tumors seem to have a distinct relation to trauma. The same type of giant-cell tumor, except much more vascular, is now and then observed in bursæ and joints. In the so-called xanthoma characterized by the presence of foam cells, giant cells of the type seen in the central giant-cell tumor of bone are either absent or present in only small numbers. But in all of these tumors containing giant cells, vascularity is a characteristic feature. The epulis bleeds when injured. If one explores the central giant-cell tumor of bone without an Esmarch, the tumor bleeds profusely, and in some cases after curetting it has been difficult to check the hemorrhage. In all of these so-called giant-cell tumors death from metastasis in the cases which I have studied has been conspicuous by its absence, while in all forms of cellular sarcoma death from metastasis to the lungs is conspicuous by its frequency.

That many central giant-cell tumors have remained well after curet-

ting and even after a second and third curetting is strong evidence of benignity, or a very low grade of malignancy.

Pathological Report (No. 6893).—*Giant-cell Tumor of Lower End of Ulna. Gross Pathology: Blood cyst; bony shell preserved. Curetting in 1905. Well, 1919; fourteen years.*

This case was reported by the late Dr. G. G. Davis, of Philadelphia (Univ. Penna. Bulletin, November, 1905, vol. xviii, p. 249). It is of especial interest not only because the giant-cell tumor had the gross appearance of a hemorrhagic bone cyst, but also because the patient, a girl, was but two and one-half years of age. There was no history of trauma. Swelling of the wrist appeared two months after an attack of tonsillitis. There was slight pain. As the swelling increased the pain lessened. The X-ray shows an expansion of the lower end of the ulna with the definite preservation of a bony shell. It looks more like a cyst than a solid giant-cell tumor. (Fig. 20.)

Dr. Davis operated nine months after the onset of the swelling. He exposed and removed a thin shell of bone and found a cavity filled with 5 cc. or more of thin, dark-brown fluid. The cavity extended upwards, gradually diminishing in size, to the middle of the shaft of the ulna. The cavity, therefore, was somewhat larger than that pictured in the X-ray. The bony shell had no distinct lining membrane. The lower portion of the cavity was filled with tumor tissue resembling reddish granulation tissue, soft in consistency. This tissue was removed with the curette, and the cavity packed with gauze. The wound healed rapidly. The microscopic report was "round-cell sarcoma with numerous giant cells."

The father of this patient, Dr. Charles C. Rankin, of Philadelphia, sent me an X-ray taken five years after operation. This showed that the bone has been restored absolutely to normal. Dr. Davis sent me some of the tissue and my sections show a typical giant-cell tumor in which there has been considerable hemorrhage. Dr. Rankin informed me in February, 1919—fourteen years after operation—that there have been no signs of recurrence.

Hemorrhagic Bone Cysts.—In my list of 47 cases this is the only example of a giant-cell tumor appearing as a hemorrhagic cyst. In one case in which the tumor was in the lower end of the femur I found a small cystic cavity, about the size of a twenty-five cent piece. In a few cases, similar to the one first reported here, there has been hemorrhage in the tumor with the formation of small and large cavities filled with blood.

Bone Aneurism. Malignant Bone Cyst.—In 1910¹ in reporting my observations on benign bone cysts and giant-cell sarcoma, I referred to three personally studied cases of the so-called "bone aneurism." In this group of tumors the bony shell is usually preserved, although in some cases it may be partially destroyed: the bone shell shows abrupt expansion. The X-ray shows no new bone formation. On exploration, this bony shell is distended with bloody fluid, and lining the shell, there is usually a narrow zone of hemorrhagic granular tumor tissue which under the microscope is composed chiefly of spindle and round cells. In some cases, mixed with these cells of the malignant sarcoma, there may be giant cells.

¹ ANNALS OF SURGERY, August, 1910; *Transactions Amer. Surg. Assn.*, 1910.

BONE TUMORS

In 1913² I again reported on the subject of bone aneurisms, and added two new cases of my own observation. Gaylord in 1903³ was first to make a comprehensive report on bone aneurisms in American literature. Later Nakayama⁴ reported three cases from Garré's clinic in Bonn and added some new cases from the literature. In 1910 Le Denuc,⁵ reported seven new cases with a resumé of the entire literature.

It is important to note here that Davis's case, in the lower end of the ulna resembles in the *gross* the so-called bone aneurism, but his patient has remained well fourteen years after a simple curetting. The majority of the cases reported in the literature died of metastasis in spite of amputation, and microscopically the tumor tissue does not resemble a giant-cell tumor, but the most malignant spindle-and-round-cell sarcoma.

Malignant sarcoma of the round-and-spindle-cell type, or of the perithelial type are often observed in the soft parts as blood cysts or hematomas. All of the cases observed by me have died of metastasis. I have suggested that the bone aneurism be called a *malignant bone cyst* in order to contrast it with the *benign bone cyst* which in my experience has never contained blood.

I propose in a second article to consider more in detail this group of tumors, but Davis's observation demonstrates that the giant-cell tumor may appear as a hemorrhagic bone cyst resembling the malignant bone cyst.

In 1902⁶ I referred to the contributions of Kramer⁷ and Jenckel⁸ who report on the benignity of giant-cell sarcomas and that they can be cured by curetting. Kramer states that now and then the giant-cell tumor may appear as a "bone blood cyst," but that one can recognize the typical giant-cell tumor tissue attached to the bone shell. He does not report any such cases in detail. The case reported by Jenckel was a blood cyst containing spicules of bone in its capsule. The tumor was in the region of the neck of the femur and arose from the trochanter minor. It was therefore a periosteal and not a central tumor. This cyst was enucleated. Giant-cell tumor tissue was found in the wall of the cyst. The patient remained well thirteen years after operation.

Pathological Report (No. 12474).—Solid Giant-cell Tumor. Lower End of the Ulna. Bony shell preserved. Resection with transplantation in 1912. Well with perfect function in 1919, seven years after operation (Figs. 21 to 24).

This patient was referred to me by the late Dr. George Ben

² *Progressive Medicine*, December, 1913.

³ *ANNALS OF SURGERY*, 1903, vol. xxxvii, page 834.

⁴ *Beitr. z. klin. Chir.*, 1909, vol. lxiv, p. 524.

⁵ *Centralbl. f. Chir.*, 1910, vol. xxxvii, p. 647.

⁶ *Progressive Medicine*, December, 1902, p. 153.

⁷ *Arch. f. klin. Chir.*, 1902, vol. lxvi, p. 792.

⁸ *Deut. Zeitschr. f. Chir.*, 1902, vol. lxiv, p. 66.

Johnson of Richmond. He was a white male aged forty-eight; eight months before operation there was a sprain of the right wrist in cranking an automobile. This was followed by some discomfort for two months. Then there was a second injury with slight increase of discomfort. Six weeks before operation, a third sprain, one week after which he observed the swelling. In a few days an X-ray (Fig. 21) was made by Doctor Gray of Richmond. This shows the preservation of a thin bony shell. The peculiar marking of the tumor shadow into irregular lobules is in my experience rather characteristic of the central giant-cell tumor.

The X-ray shows that the styloid process is involved, but its contours are as yet not distorted.

In this case I decided that it was better, in view of the thin bony shell, to resect and transplant rather than curet. This operation could be done as quickly and *promised equally good function*. The resection was done February 23, 1912. The transplant was taken from the shaft of the ulna above and is shown in Fig. 23. The wound healed, the patient had only a short period of disability, there has been no loss of function, and the patient is able to crank and run his automobile (Fig. 23).

Gross Pathology.—The cut surface of the tumor (Fig. 24) shows a distinct bone capsule, and the cavity is filled with the typical granular reddish-brown giant-cell tumor tissue. We could also observe here and there small whitish areas firmer in consistency which resembled the *ostitis fibrosa* of the bone cyst. The sections from this tumor show typical giant-cell tissue and areas of *ostitis fibrosa*.

Summary.—These three cases situated in the lower end of the ulna are examples of the three types of the giant-cell tumor.

Pathological Report No. 12474 corresponds in its X-ray picture, in the preservation of the bony shell and in the presence of a solid tumor filling the bony shell, to the more common appearance of the giant-cell tumor, irrespective of its situation.

Pathological Report No. 23852 represents a less frequent type in which the tumor is filled with small and large cavities containing blood and resembling somewhat a cavernous angioma, and also one in which the bony shell has been destroyed.

Pathological Report No. 6893 is practically unique in my series in that the marrow tumor is chiefly a blood cyst.

In the fourth type of giant-cell tumor there is a perforation of the bony shell or fibrous capsule with infiltration of tumor tissue into the surrounding soft parts. This variety was not observed in the tumors involving the lower end of the ulna.

Hemorrhage Into the Giant-cell Tumor.—In my own cases and from the description of other surgeons the giant-cell tumor always looks vascular. On the whole, it resembles *œdematous granulation tissue*, but it is much more friable, because it has no intercellular fibrous-tissue stroma, nor elastic tissue. It is apparently composed of endothelium-lined vessels

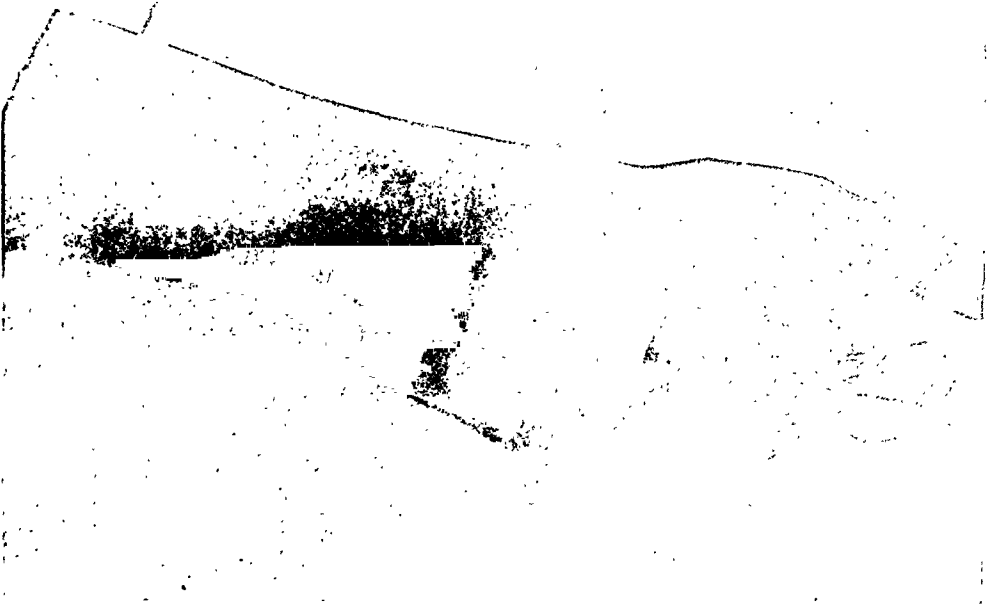


FIG. 1.—Pathological Report No. 23852. Central giant-cell tumor of lower end of ulna. Colored female, aged twenty-six; swelling one year; clinically like a malignant sarcoma (malignant hemorrhagic bone cyst).



FIG. 2.—Pathological Report No. 23852. X-ray of giant-cell tumor of lower end of ulna showing almost complete destruction of bony shell. Anteroposterior view. This picture shows that there is no destruction of the radius or carpal bones. Compare with Fig. 4. (X-ray sent by Dr. Marvel.)

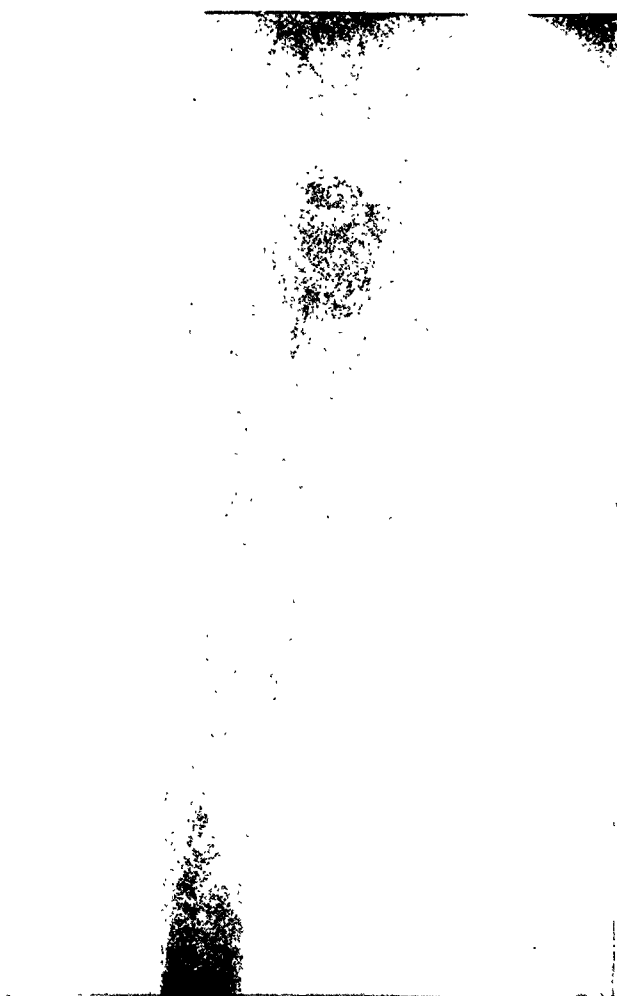


FIG. 3.—Pathological Report No. 23852. Lateral view (see Fig. 2). Compare with Fig. 4. X-ray sent by Dr. Marvel.



FIG. 4.—Pathological Report No. 23852. X-ray taken by Dr. Kahn at St. Agnes Hospital. Central giant-cell tumor of lower end of ulna of patient shown in Fig. 1. Compare with Figs. 2 and 3. Note the almost complete destruction of the bony shell, but the tumor is still circumscribed.

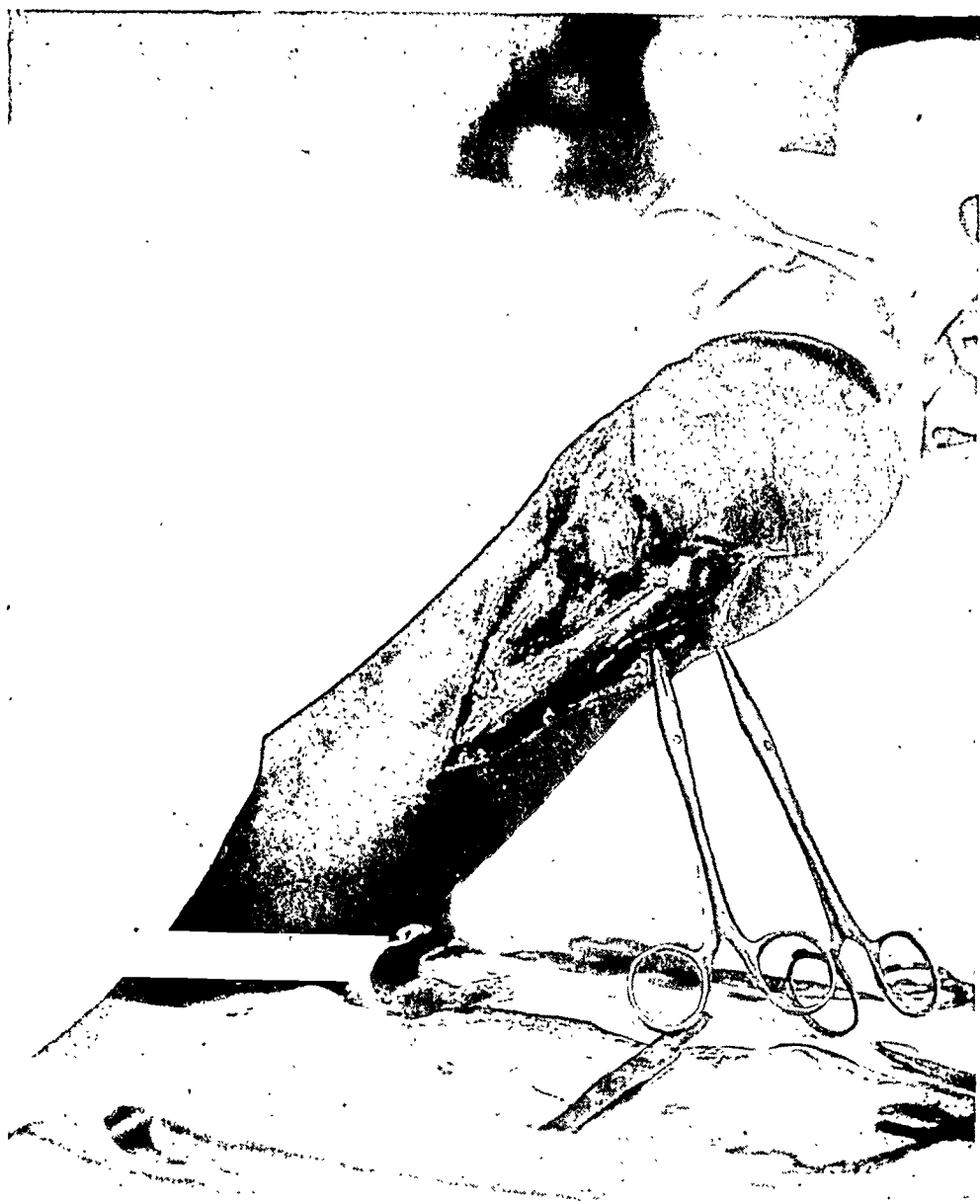


FIG. 5.—Pathological Report No. 23852. First step in operation on tumor shown in Fig. 1. The skin incision, exposure of ulna bone marking out of skin area to be removed.



FIG. 6.—Pathological Report No. 23852. Second stage of operation on tumor shown in Fig. 1. The ulnar nerve is being retracted in its dissection from the tumor. The sponge, wet in alcohol, is covering a small opening in the capsule of the tumor from which clear serum had escaped.



FIG. 7.—Pathological Report No. 23852. Third stage in the operation on tumor shown in Fig. 1. The bone forceps is biting off the ulnar side of the lower end of the radius. The tumor is now almost isolated.



FIG. 8.—Pathological Report No. 23852. The last stage in the operation for the removal of the tumor shown in Fig. 1. The tumor is still attached to the lower portion of the extensor carpi ulnaris. The uninvolvement of tendons and muscles and carpal bones are pictured and the ulnar nerve is retracted by a loop of fine black silk.



FIG. 9.—Pathological Report No. 23852. The closure of the wound after the local excision of the tumor shown in Fig. 1. Had less skin been removed with the tumor the narrowing of the forearm at the wrist would have been less marked.

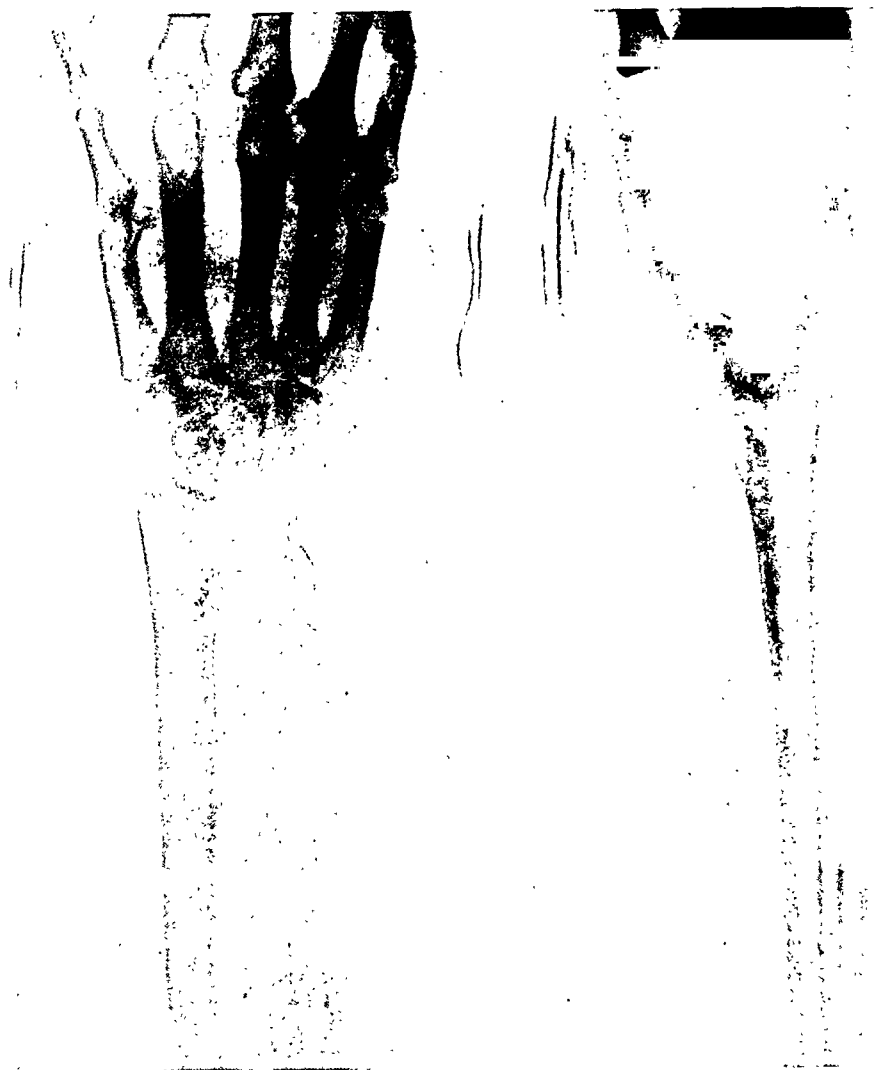


FIG. 10.—Pathological Report No. 23852. Anteroposterior and lateral X-rays by Dr. Kahn after the resection of the lower end of the ulna with the tumor shown in Fig. 1. This shows the piece of radius removed and the defect due to the removal of two carpal bones; also the narrowing of the forearm at the wrist due to excising of more skin than necessary.



FIG. 11.—Pathological Report No. 23852. X-rays (anteroposterior and lateral) about ten days after bone transplantation from the tibia into the defect shown in Fig. 10. The pin of the transplant is seen in the marrow cavity of the upper end of the ulna. In the lateral view it appears as if this pin had fractured. Clinically there is no evidence of fracture at this junction.



FIG. 12.—Pathological Report No. 23852. The removed skin, subcutaneous fat, capsule of tumor and piece of ulna of the tumor shown in Fig. 1. The examination of this specimen demonstrates that more skin could have been saved. The divided extensor tendon to the little finger is shown.



FIG. 13.—Pathological Report No. 23852. Surface appearance of a longitudinal section through the specimen of tumor shown in Fig. 1 after it had been in formalin a few days. The cavities which were filled with blood are pictured. The capsule is distinctly shown. Compare with Fig. 14.



FIG. 14.—Pathological Report No. 23852. Photograph of fresh cut through the formalin specimen. The spongy angiomatic character is shown in the many small and large cavities throughout the tumor. The irregular white septa are due to organized fibrin. The infiltration of the capsule is pictured. Compare with Fig. 13.

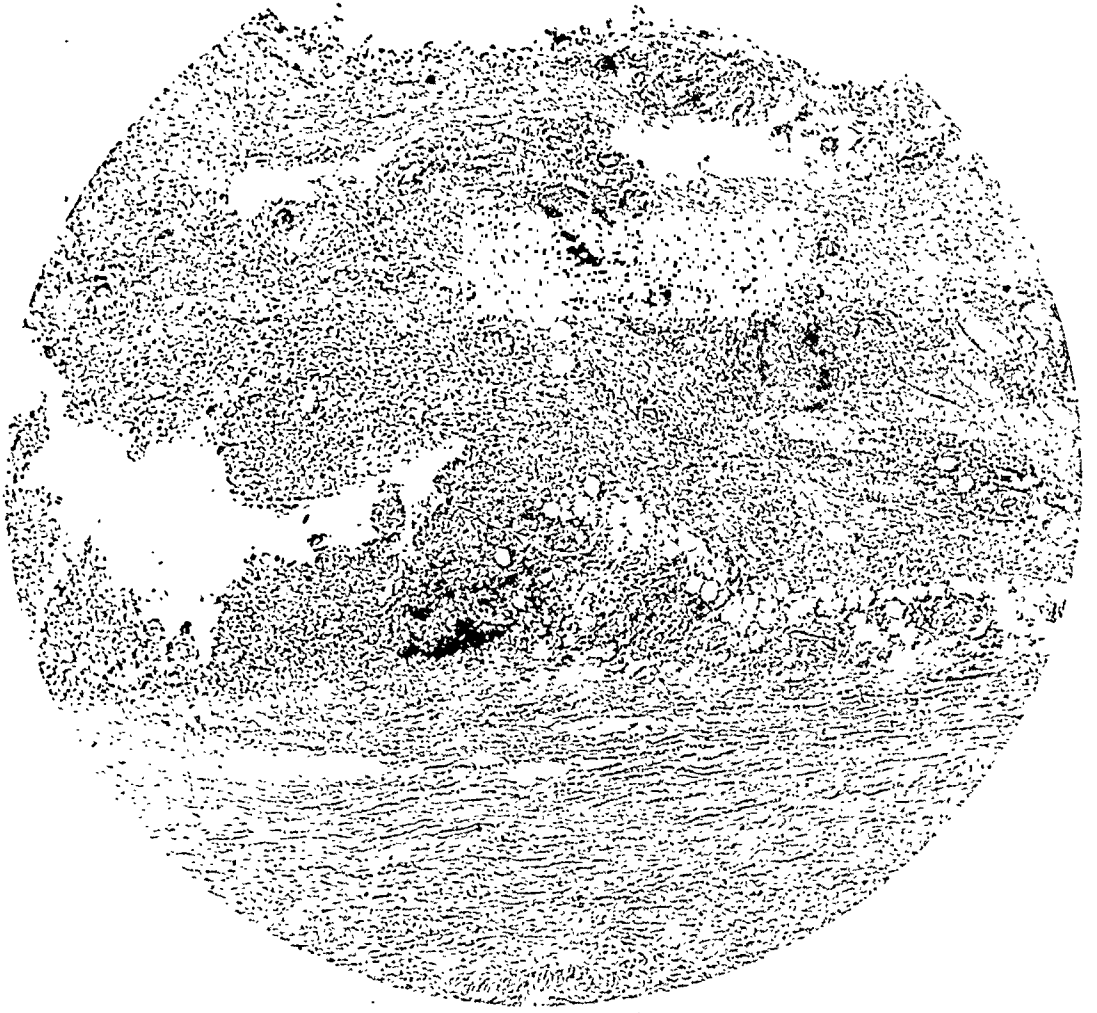


FIG. 15.—Pathological Report No. 23852. Photomicrograph (low power) of capsule of giant-cell tumor of lower end of ulna showing infiltration of capsule with vascular giant-cell tissue.

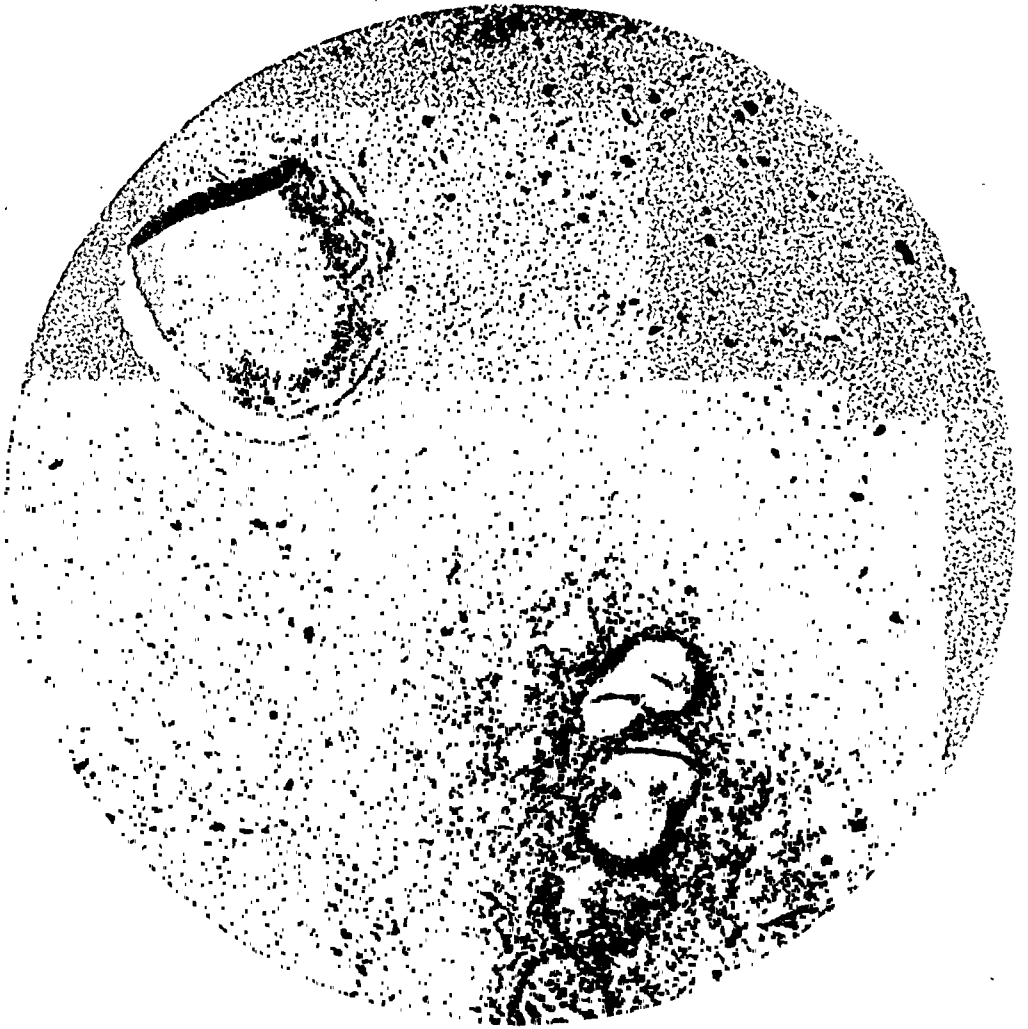


FIG. 16.—Pathological Report No. 23852. Photomicrograph (low power) illustrating the giant-cell tumor infiltrated with blood and blood cavities.

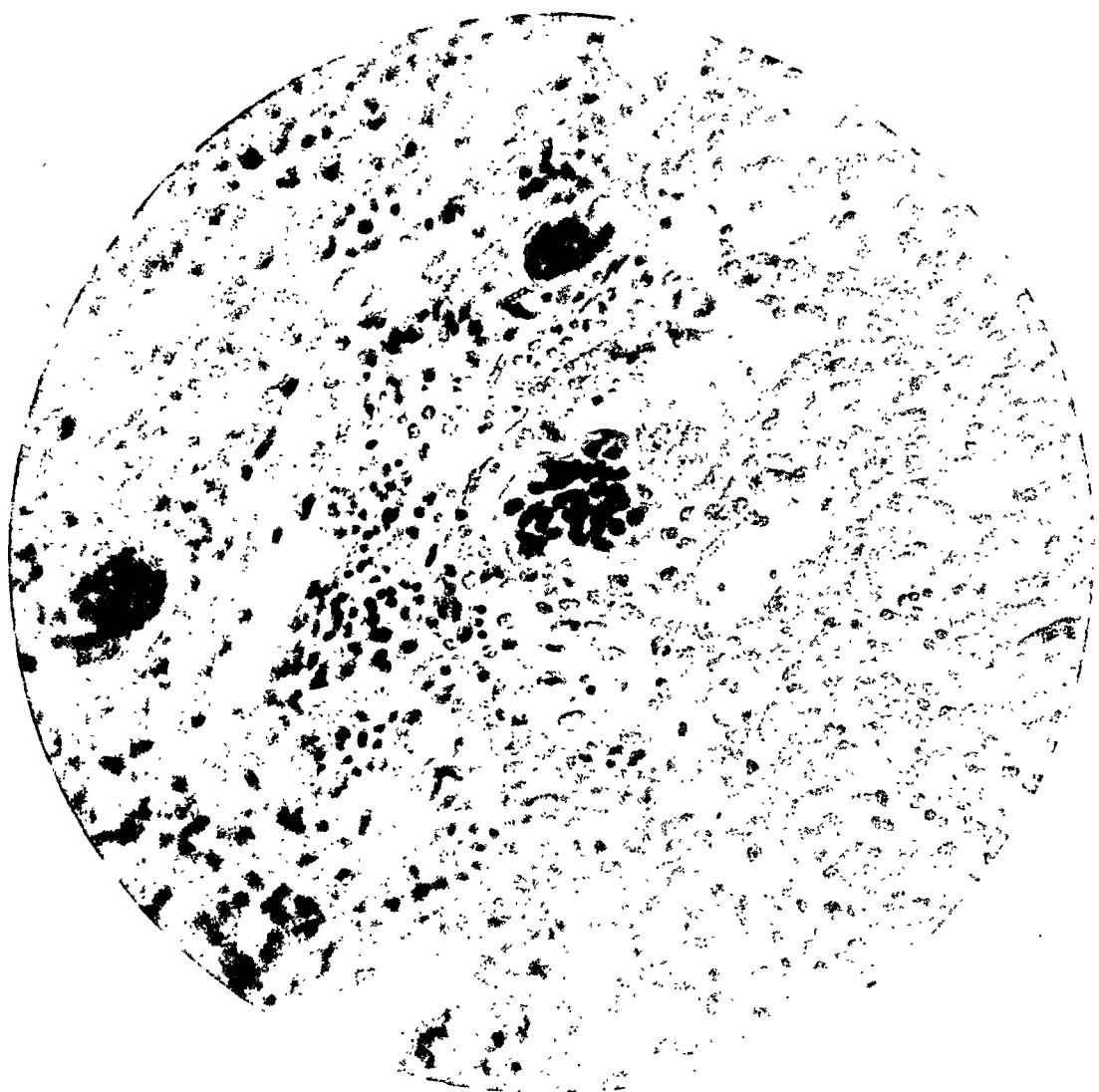


FIG. 17.—Pathological Report No. 23852. Photomicrograph (high dry power) showing the giant-cells imbedded in the vascular, cellular tumor tissue. This tumor tissue should easily be distinguished from a spindle-and-round-cell sarcoma. It resembles granulation tissue, or a very cellular capillary angioma.

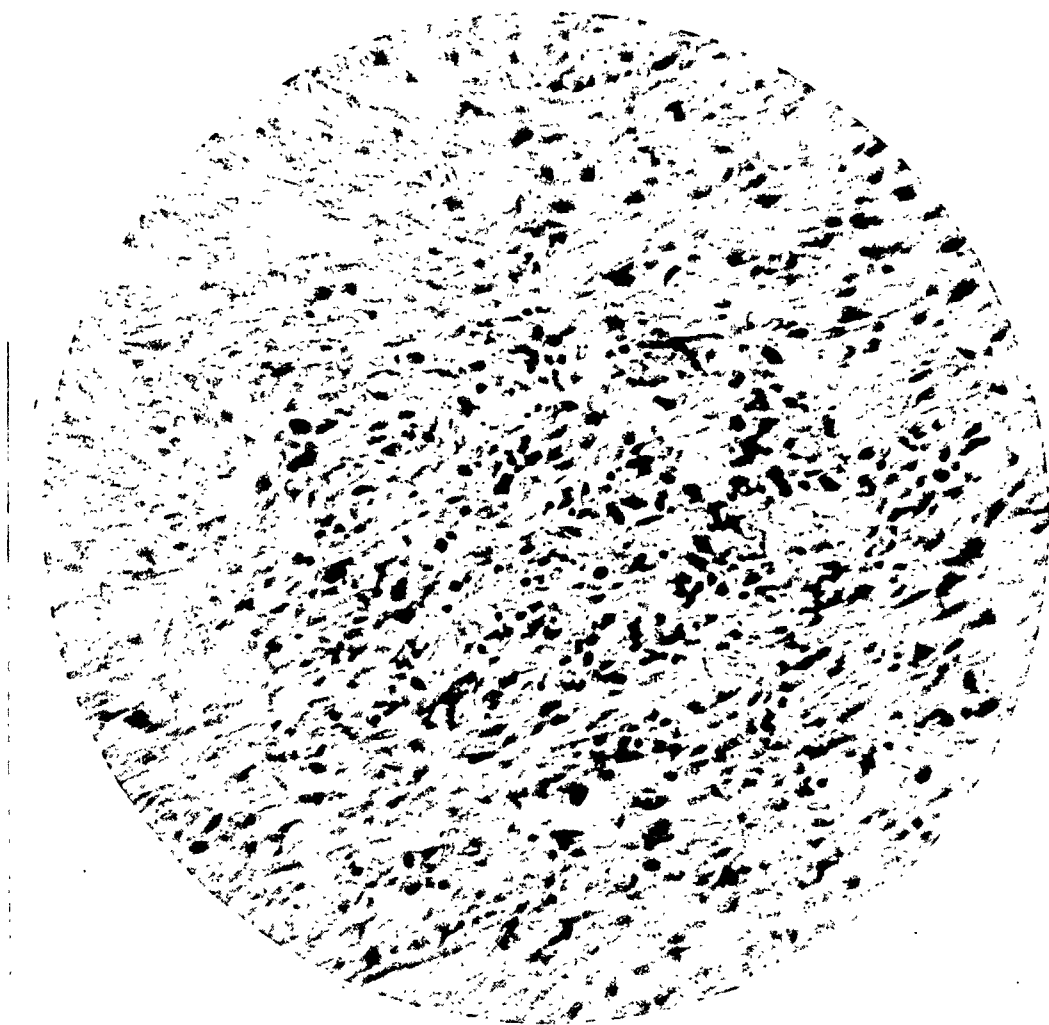


FIG. 18.—Pathological Report No. 23852. Photomicrograph (high dry power) of cellular tumor tissue in which there are no giant cells. Compare with Fig. 17.

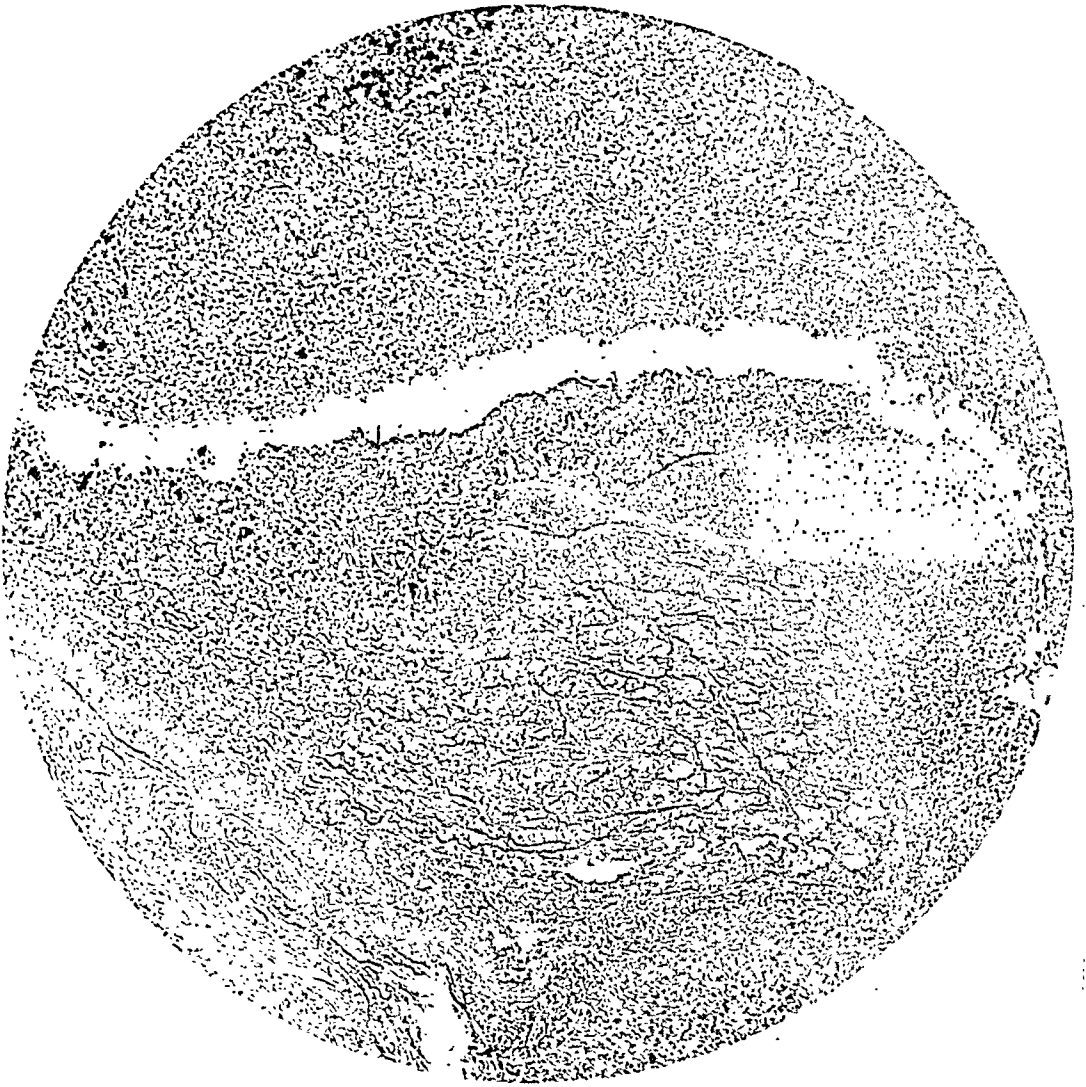


FIG. 19.—Pathological Report No. 23852. Photomicrograph (lower power) of an area of organized fibrin below from the white areas shown in Fig. 14 and the giant-cell tumor tissue above.

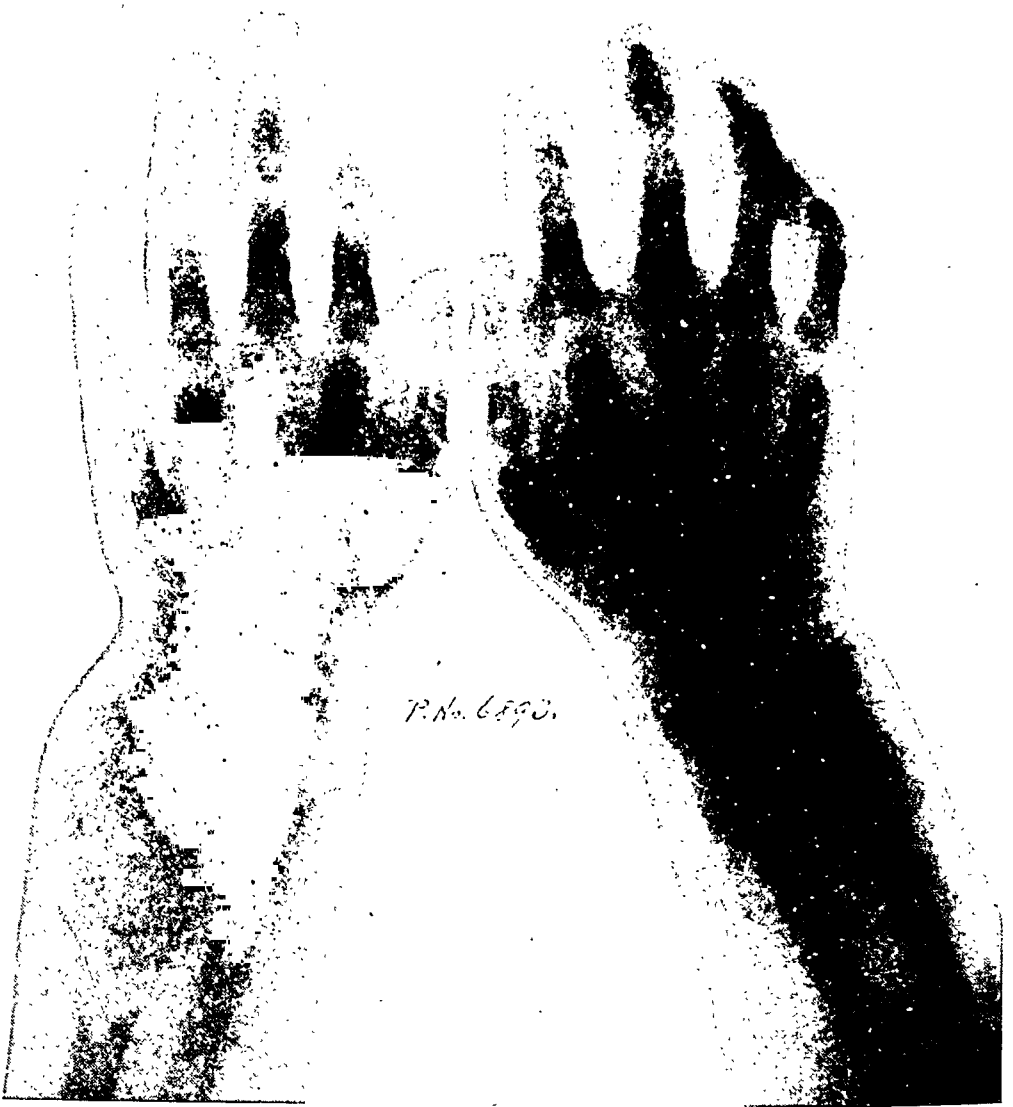


FIG. 20.—Pathological Report No. 6893. Giant-cell tumor of lower end of ulna. Davis's case. Previously reported in ANNALS OF SURGERY, August, 1910, vol. lii, Fig. 29.



FIG. 21.—Pathological Report No. 12474. X-ray of central giant-cell tumor of lower end of ulna. White male, aged 48; trauma eight months; pain, swelling two weeks. The bone capsule is distinctly preserved; the markings are those usually seen in the giant-cell tumor. This case has been reported in *ANNALS OF SURGERY*, Aug., 1912, vol. lvi.

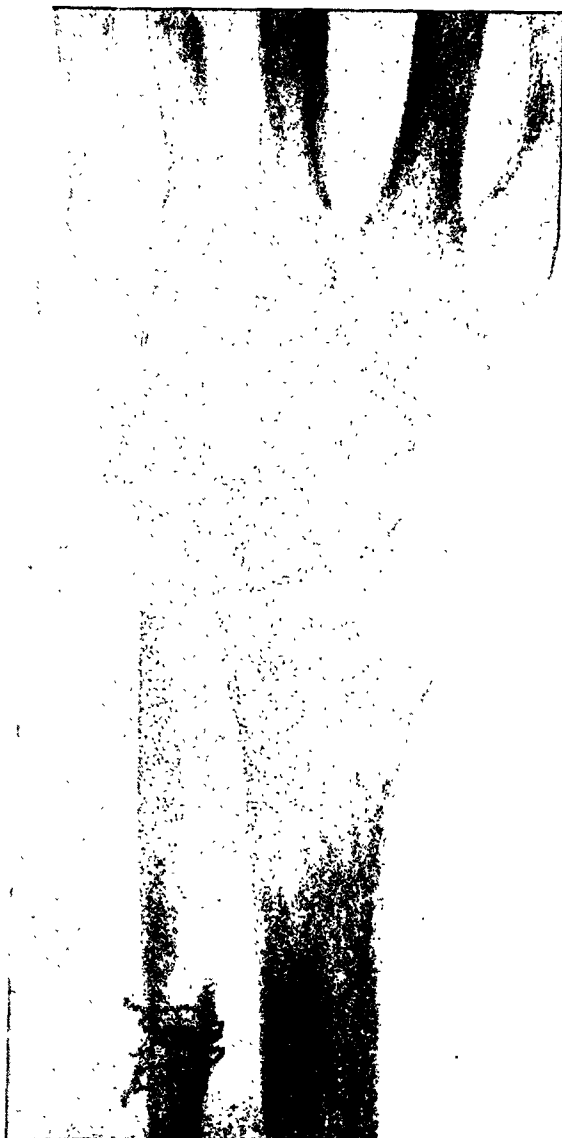


FIG. 22.—Pathological Report No. 12474. X-ray after transplantation of piece of ulna in case shown in Fig. 21. (Previously reported in *ANNALS OF SURGERY*, August, 1912, vol. lvi, Fig. 29).



FIG. 23.—Pathological Report No. 12474. X-ray two years after operation on case shown in Figs. 21 and 22. The transplant has united by perfect bony union with the ulna. There is no restriction of function of the wrist, and weakness of the arm. (Not previously reported.)



FIG. 24.—Pathological Report No. 12474. Photograph of bisected tumor after resection. See Fig. 21 for X-ray. This is the usual gross appearance of the giant-cell tumor. Compare with Figs. 13 and 14 which illustrate unusual appearance of the giant-cell tumor. (Previously reported in ANNALS OF SURGERY, August, 1912, vol. lvi, Fig. 28.)



FIG. 25.—Pathological Report No. 8680. Photograph of resected gross specimen of giant-cell tumor of lower end of radius, to show the absence of a bony shell and the gross appearance of a giant-cell tumor with red areas and areas of osteitis fibrosa. (Previously reported in ANNALS OF SURGERY, August, 1910, lvi, Fig. 37.) Compare this with Figs. 13, 14 and 24.

BONE TUMORS

containing blood surrounded by loose young cellular connective tissue, and throughout this tissue there are numerous giant cells. The color of the giant-cell tumor must be due to its vascularity, yet pulsation has been observed in but two cases. When the tumors have been curetted from the bony shell, all operators have noted the great hemorrhage from vessels perforating the bony shell. When I curetted a giant-cell tumor of the upper end of the tibia in December, 1902,⁹ and removed the Esmarch the bleeding was so profuse that we had to replace the Esmarch and pack the bone cavity with gauze, using a chisel and a hammer. This patient is well in 1919, seventeen years since operation.

Dr. Frank Hinds,¹⁰ of England, who was first to curet a very large giant-cell tumor in the lower end of the femur, reports a similar experience. He also had to use a tourniquet and to pack. Doctor Taylor, of Philadelphia, had an experience similar to Hinds's.

In view of this great vascularity it would not seem unexpected to observe even more frequently evidences of hemorrhage into the giant-cell tumor tissue similar to the first case reported in this article, or even sufficient to produce a blood cyst resembling Davis's case. But on the whole this extreme hemorrhage has not been observed except in a few cases. With the exception of Davis's case marked hemorrhage into the tumor tissue as pictured in the first case reported here, has only been noted when the bony shell had been completely or partially destroyed. The destruction of the bony shell would undoubtedly allow the vascular tumor tissue to be subjected to trauma more readily and this explains the hemorrhage.

Evidence that Perforation or Destruction of the Bony Shell by the Giant-cell Tumor does not Indicate Increased Malignancy of the Tumor.—My conception of malignancy in sarcoma is metastasis to the internal organs or neighboring lymphatics. In the Surgical Pathological Laboratory of the Johns Hopkins Hospital we have recorded a large number of periosteal and central sarcomas of bone and sarcoma of the soft parts and glands. The vast majority of these patients have died of metastasis to the lungs without local recurrence. The usual type of the tumor is spindle-and-round-cell sarcoma, sometimes with a perithelial arrangement. In these 47 cases of giant-cell tumor there is not a single example of death from any cause which could be attributed to the tumor. In many instances the local growth of the sarcoma which has caused death by metastasis, had been just as circumscribed and, in some instances, more circumscribed, than the local growth of the giant-cell tumor. The size of the local growth which produced death by metastasis is not necessarily large.

⁹ *Johns Hopkins Hosp. Bull.*, May, 1903, vol. xiv, p. 133; *Progressive Medicine*, December, 1903, page 201.

¹⁰ *British Med. Jour.*, February 26, 1898; *Progressive Medicine*, December, 1899, page 242.

It is therefore of the utmost importance, especially in relation to bone tumors, to be able to recognize the giant-cell tumor, because when it is recognized a cure should be accomplished with little or no mutilation *beyond that due to the destruction by the tumor itself.*

Giant-cell Tumor of the Lower End of the Radius. Thirteen Cases.—The bony shell had been more or less completely destroyed in four cases, perforated in two cases; it was completely intact in six cases, and in one case the tumor had recurred after resection of the lower end of the radius, and the condition of the shell in the original tumor could not be ascertained.

Pathological Report (No. 738).—Observed in the Johns Hopkins Surgical Clinic in 1894. The bony shell was completely destroyed; tumor tissue had broken through the capsule into the area of the carpal bone; the tumor was filled with blood; it pulsated. This patient is well 1919, twenty-five years after amputation.

Pathological Report (No. 2420).—I operated on this case in Johns Hopkins Hospital in 1901. On making an exploratory incision there was no bony shell; the tumor was very cellular and very hemorrhagic. It was my opinion then that it was a very malignant round-cell sarcoma of the perithelial type. The arm was amputated above the elbow. The gross specimen shows complete destruction of the bony shell, perforation of the capsule, infiltration of tumor tissue along the tendon sheath to the thumb. This patient was well in 1915—fourteen years since operation.

Pathological Report (No. 8680).—(Fig. 25.) Observed in the Johns Hopkins Surgical Clinic in 1908. The operation consisted of resection of radius, ulna' and carpal bones. The gross specimen shows that the tumor is confined within a definite fibrous capsule, and the ulna and carpal bones are not involved. There was no perforation of the fibrous capsule. The tumor was composed of typical giant-cell tissue with areas of *ostitis fibrosa*. Resection of the lower end of the radius would have been sufficient. This patient is well 1919—eleven years since operation, and has very good function of the hand. She is able to do all her housework.

Pathological Report (No. 14044).—Observed in 1909 by Dr. Emil G. Beck, of Chicago. The bony shell was almost completely destroyed and the metacarpal bones were involved. Dr. Beck first curetted thoroughly. One year later because of recurrence he amputated the arm. This patient was well in 1915—six years since operation.

Pathological Report (No. 6125).²¹—In this case the bony shell was preserved, except at one point towards the radius where there was a slight perforation. The operation in 1905 at the Johns Hopkins Surgical Clinic consisted of resection of the lower ends of both bones. This patient was well in 1915—ten years since operation. From a study of the X-ray plate and the specimen, I am inclined to think curetting should have been tried first. The giant-cell tumor in the lower end of the radius with the exception of this perforation at one point is no more extensive than in Pathological Report No. 10376, curetted by Dr. Chambers, of Baltimore, in 1908 and well in 1919—eleven years since operation.

Pathological Report (No. 16720).—Operation by Dr. Harry M. Sherman, of San Francisco, in 1914. Dr. Sherman resected the lower end of the radius and some of the carpal bones, because the tumor had perforated the capsule and involved the carpal bones. This, however, does not show in the X-ray print sent to me. The patient is well in 1919—five years since operation.

Giant-cell Tumor of the Lower End of the Femur. Ten Cases.—In none of these cases was the bony shell completely destroyed, but in four cases there was perforation of the bony shell, with involvement of the soft parts in the popliteal space.

²¹ ANNALS OF SURGERY, August, 1912, vol. lvi, Fig. 16.

BONE TUMORS

Pathological Report (No. 2458).—Observed in the Johns Hopkins Surgical Clinic in 1899. The growth was first resected and then seven days later the limb was amputated through the thigh. Nine years later this patient's abdomen was explored in the Johns Hopkins Clinic and an inoperable cancer of the stomach found, which apparently had no relation to the previous bone tumor.

Pathological Report (No. 3623).—Observed in the Johns Hopkins Surgical Clinic in 1900. As the symptoms were those of gonorrhœal arthritis, there was a number of exploratory arthrotomies. The leg was amputated five months later. This patient died ten years later of tuberculosis of the lungs.

Pathological Report (No. 4396).—The thigh was amputated in the Johns Hopkins Clinic in 1903. The patient is well in 1919—fifteen years since operation.

Pathological Report (No. 13214).—Operated on in the Johns Hopkins Clinic in September, 1912. Resection of the lower end of the femur. Bone transplanted from the tibia. This patient is well in 1919, almost seven years since operation.

When we compare the ultimate results in these four cases of giant-cell tumor of the lower end of the femur which had perforated into the soft parts of the popliteal space with the spindle-and-round-cell sarcoma of the lower end of the femur with similar involvement of the soft parts, we find in the latter group every patient dead of metastasis within three years in spite of high amputation.

Giant-cell Tumor of the Tibia. Eleven Cases.—In only one case was the bony shell partially destroyed, and in one instance there was a small perforation of the bony shell.

Pathological Report (No. 10975).¹²—The tumor involved the upper end of the tibia. The X-ray resembled very closely the first case reported here. There was practically no bony shell. I resected this in 1910, and did a secondary bone transplantation. The patient is well in 1919—eight and one-half years since operation.

Pathological Report (No. 12207).¹³—The tumor involved the upper third of the shaft of the tibia. Dr. A. R. Kimpton, of Boston, operated in November, 1911, and noted that the periosteum and bony shell were perforated at one point. The operation consisted of curetting. This patient was well in 1915—four years since operation.

I have given this evidence in detail to emphasize the statement that destruction of the bony shell, partial or complete, or perforation and infiltration of the soft parts by the giant-cell tumor is not associated with metastasis and does not indicate a more radical procedure, beyond the removal of the tumor.

Evidence that Exploratory Incision and Recurrence do not Increase the Malignancy of the Local Growth of the Giant-cell Tumor.—This fact is of the greatest importance in justifying a less radical procedure, running the risk of a recurrence, if a more radical operation would mean amputation, or a resection with limited function.

Pathological Report (No. 8412).¹⁴—This patient came under my observation in 1907 with a recurrent tumor in the position of the lower end of the radius. The onset

¹² ANNALS OF SURGERY, August, 1912, vol. lvi, Figs. 17 to 23.

¹³ ANNALS OF SURGERY, August, 1912, vol. lvi, Figs. 11 and 12.

¹⁴ ANNALS OF SURGERY, August, 1912, vol. lvi, Fig. 14.

of the tumor had been twenty months before my operation. There had been three previous operations—two incomplete curettings and one resection of the lower end of the radius. The recurrent tumor was distinctly encapsulated, situated in the soft parts between the resected ends of the radius and the carpus. It was a typical giant-cell tumor. I was rather of the opinion that the recurrence was due to tumor transplant at one of the previous operations. I removed the tumor without injury to any of the tendons and transplanted a piece of ulna into the defect. This patient died seven and one-half years later from a cardiac lesion present at the time of my operation.

Pathological Report (No. 1815).¹⁵—In this case the tumor was in the lower end of the radius. There had been an exploratory incision fourteen months before the operation at the Johns Hopkins Clinic in May, 1897. I assisted Doctor Halsted at this operation. The tumor was explored. In spite of the previous operation the bony shell had healed completely and there was no tumor tissue outside the bony shell. The explored tumor was vascular and pigmented. At that time (1897) our diagnosis was a cellular sarcoma of malignant type. The arm was amputated, and the enlarged epitrochlear and axillary glands were removed. The tumor proved to be a giant-cell growth. The enlarged glands contained blood pigment, but no tumor cells. This patient is well in 1919—twenty-two years after operation. This case has been reported in the *ANNALS OF SURGERY* for August, 1912, vol. lvi, p. 210.

Pathological Report (No. 14044).—This case has been mentioned before as the bony shell was destroyed and the carpus infiltrated. Dr. Emil G. Beck, of Chicago, curetted the giant-cell tumor in the lower end of the radius in 1909 and amputated for a recurrence in 1910. The patient was well in 1915.

Pathological Report (No. 7440).¹⁶—Dr. William J. Taylor, of Philadelphia, curetted a giant-cell tumor in the lower end of the femur in 1906; encountered extreme hemorrhage and was compelled to pack the cavity; curetting was probably incomplete. The leg was amputated about one year later for a recurrence. This patient was well in 1918—eleven years since operation.

Pathological Report (No. 7851).¹⁷—Giant-cell tumor of the lower end of femur. The late Dr. John B. Murphy, of Chicago, explored and removed a piece for diagnosis. Some weeks later Dr. James F. Mitchell, of Washington, amputated the thigh. This patient was well in 1914—seven years since operation.

Pathological Report (No. 12926).¹⁸—Giant-cell tumor in upper end of fibula. This was curetted in 1911 by Dr. John W. Chambers, of Baltimore. It was resected for recurrence in 1915. The patient is well in 1919.

Recurrence After Operation for Benign Connective-tissue Tumors.—For years I have been interested in this observation, especially in the mixed tumors of the parotid, the intracanalicular myxoma of the breast, the myxoma of bone, the giant-cell epulis of the alveolar border of the jaws, the fibromyxoma of nerve-sheaths, and now and then in lipomas.

When recurrence has taken place in these groups of benign connective-tissue tumors, the operation had consisted in a rough enucleation. I have demonstrated in such tumors that the capsule is thin, and if torn pulls away with small particles of tumor tissue. At an operation of enucleation, therefore, if the capsule is torn, particles of tumor tissue could

¹⁵ *ANNALS OF SURGERY*, August, 1912, vol. lvi, Fig. 34.

¹⁶ *ANNALS OF SURGERY*, August, 1910, vol. lii, Fig. 31.

¹⁷ *ANNALS OF SURGERY*, August, 1910, vol. lii, Fig. 38.

¹⁸ *ANNALS OF SURGERY*, August, 1912, vol. lvi, Figs. 7, 8 and 9.

be left in the wound and their later growth would produce a recurrence. There is no question as to the fact of recurrence.

I have reoperated upon at least seven of such recurrent tumors in the region of the parotid, and when I could not excise because of injury to the facial nerve, I have enucleated, disinfecting the wound with pure carbolic and alcohol. There have been no recurrences. In the intracanalicular myxoma of the breast one can always excise and there has never been recurrence after these secondary complete excisions. In the older text books on surgery written by surgeons well trained in the pathology of tumors we frequently find the statement that the "pure myxoma of bone is a benign tumor, but that it usually recurs."

My records confirm this statement, but unfortunately in myxoma of bone the recurrent tumor often shows sarcomatous degeneration. This is also true of the fibromyxoma of nerve sheaths. Such tumors, therefore, should never be enucleated and not explored. If either is necessary, in order to establish the diagnosis or restrict mutilation, the wound should be swabbed with pure carbolic acid followed by alcohol, or the cautery should be employed. Personally, I have never had a recurrence when this technic has been followed. The object of this method is to destroy particles of tumor tissue that might be left in the wound when the tumor is explored or enucleated. The danger is greater in enucleation, but in myxoma of bone simple exploration seems to be sufficient.

When the giant-cell tumor of the alveolar border of the upper jaw is removed with the knife, recurrences are frequent; when removed with the cautery, there have not been any recurrences, and the operation has been less extensive.

The recurrences in lipoma have apparently been due to rough enucleation. I have one example in which the lipoma recurred three times in its situation in the thigh near the femoral vessels. These recurrences took place within three years. It is now more than four years since the operation performed by me in which the tumor was given a wide berth, except where it was adherent to the femoral vessels; at this point an alcohol sponge was employed, and the sheath of the vessel was removed. There has been no recurrence.

In fibromyxoma of nerve sheaths no attempt should be made to save the nerve trunk, if the tumor surrounds it. The nerve should be resected, because, although the original tumor may be benign, the recurrent tumor may be sarcoma and associated with metastasis.

I take space for this evidence here, because in my opinion some of the recurrences after curetting for giant-cell tumor may be explained by the neglect of cleansing the bony shell with some agent which will destroy remains of tumor tissue. I have always employed pure carbolic acid followed by alcohol. Hinds, after curetting a tumor in the lower end of the femur, packed the cavity with gauze saturated with chloride of zinc. As far as I can ascertain, all the successful cases of curetting for central

giant-cell tumor have had, in addition to a thorough curetting, some such method of chemical cauterization. One could employ the cautery.

Curetting for Giant-cell Tumor.—In 1899, nineteen years ago,¹⁹ I reviewed the literature on the conservative treatment of sarcoma of the long pipe bones, and in that contribution I referred to the observation of Frank Hinds.²⁰ The giant-cell tumor filled the lower end of the femur and its condyles. The preoperative diagnosis was osteomyelitis. When Hinds explored and removed the expanded thin bony shell he exposed tumor tissue "dark-red in color," which could be easily scraped out with a sharp spoon. The bleeding was so profuse that an Esmarch had to be placed on the thigh. Hinds notes that the tumor involved both condyles and extended up the shaft for a depth of four inches. After curetting thoroughly the surface of the remaining bony shell was "scrubbed" with a solution of chloride of zinc and packed with gauze. Six weeks later the granulation tissue lining the bony shell looked suspicious, so that curetting and scrubbing with chloride of zinc was repeated. The microscopic sections of the curetted tumor showed "myeloid sarcoma with numerous giant cells." There was no microscopic study of the tissue removed at the second operation.

Doctor Hinds sent me sections of this tumor in 1914 (Pathological Report No. 13025). They show a typical giant-cell tumor. In 1916 Doctor Hinds wrote me from the war zone in France and enclosed a letter from this patient twenty-one years after operation. The patient has perfect function and works as a forester cutting down trees; carrying heavy weights and walking from ten to twelve miles a day. An X-ray print²¹ was also sent me, demonstrating that the cavity is filled with bone.

This case of Hinds's represents the most extensive central giant-cell tumor treated by curetting, and the result in this case should encourage surgeons to use this method more frequently.

Among the ten examples of giant-cell tumor in the lower end of the femur in my list, curetting in at least eight cases offered as much chance of a permanent cure as in Hind's case. Yet, it was tried only in one other case, by Doctor Taylor,²² of Philadelphia. The failure in Doctor Taylor's case, I think, was due to incomplete curetting because of the hemorrhage. I have the specimen removed at the later amputation, and I am of the opinion that it would have been justifiable to attempt a curetting a second time, using the Esmarch and some form of cauterization of the bony shell.

I have furnished the evidence that there is no risk in recurrence. In tumors of the lower end of the femur resection and bone transplantation rarely give as good function as amputation and an artificial limb. Curet-

¹⁹ *Progressive Medicine*, December, 1899.

²⁰ *Ibid.*, p. 242; *British Med. Jour.*, February 26, 1898.

²¹ *ANNALS OF SURGERY*, August, 1912, Fig. 33.

²² *ANNALS OF SURGERY*, August 1910, vol. lii, Fig. 31.

ting, therefore, offers the only method of a cure with perfect restoration of function.

In December, 1902, I had my first opportunity to try curetting. The giant-cell tumor involved the upper end of the tibia. This case has been reported.²³ The tumor was not as extensive as that operated on by Hinds. The patient was well in 1915—thirteen years later.

In the *ANNALS OF SURGERY* for August, 1910 (vol. lii), I reported on the cases which have been cured by curetting: Hinds's case in the lower end of the femur and my case in the upper end of the tibia just mentioned, Davis's case in the lower end of the ulna, again reported in this paper, and one in the lower end of the radius, curetted by Doctor Chambers. In *ANNALS OF SURGERY* for August, 1912, I made a further report mentioning cases from the literature. As far as I know there has been no recurrence in any of these cases. I have not gone over the literature since 1912.

Doctor Howard L. Prince, of Rochester, N. Y., wrote me in November, 1918, that he had curetted the following cases with good results: Upper end of the tibia, well five years; os calcis, two cases, well three and four years respectively after operation; upper end of ulna, one case, well six years after operation. Doctor Prince after curetting cauterizes the bone cavity with carbolic acid followed by alcohol.

I have seen the X-rays and tissue in most of these cases operated on by Doctor Prince.

CONCLUSIONS

I am confident that surgeons and pathologists should and can learn to recognize the central giant-cell tumor at the exploratory incision, and when it is recognized and its benignity accepted, there undoubtedly will be more cases subjected to curetting, and resection will only be done when made necessary by the complete absence of the bony shell, or when resection will leave the limb with equally good function.

My experience shows that we are seeing bone tumors of all types in an earlier stage, and it is essential that the different types be recognized at the exploratory incision.

In the contribution to the *ANNALS OF SURGERY* for August, 1910, full bibliography is furnished up to that date on Bone Cysts and Multiple Bone Lesions. In the article in August, 1912, some of the literature on giant-cell tumors is given. In the December numbers of *Progressive Medicine*, from 1899 to 1918, the literature on bone tumors is critically reviewed.

²³ *Johns Hopkins Hospital Bulletin*, May, 1903, vol. xiv, p. 133; *Progressive Medicine*, December, 1903, p. 201; *ANNALS OF SURGERY*, Aug., 1910, vol. lii, Figs. 24 to 28.

FURTHER STUDIES IN OSTEOGENESIS

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DESPITE the intensive study of bone growth called into being by Macewen's stimulating monograph¹, our knowledge of the exact changes which occur in the autogenous bone graft subsequent to transplantation, is in many respects meagre and uncertain. There are to-day at least two views relative to osteogenesis. The first, that advocated by Macewen, who maintains that osteogenetic activity resides in the bone cells, that osteoblasts pour out of the bone subsequent to injury or transplantation, and that the periosteum acts merely as a limiting membrane. The other view, dating from the classical research of Ollier (Paris, 1867) supported by the thorough experimental work of Axhausen, emphasizes the importance of the periosteum as the essential bone producing tissue. According to the first view, the bone cells live subsequent to transplantation, multiply and are capable of the same activity as transplanted epidermal cells. According to the opposing view, the bone cells die and regeneration occurs through the activity of the transplanted periosteum and of the adjacent bone into which the transplant has been inserted; in other words, the transplant acts merely as a scaffolding. This important discrepancy brings in its train other divergencies of opinion, concerning not only the histological processes, but, as a sequence of these theoretical differences, varying opinions concerning the best operative technic. Thus, for instance, Gallie believes in the use of boiled bone rather than the autogenous, living graft on the basis of the theory that the graft acts merely as a scaffolding.

It is in the hope of adding a little to our exact knowledge of the fate of the bone graft, that this paper is written. It should be of value, since the material, although limited to two specimens, has been derived not from animal experimentation, but from human autopsies.

The first specimen is from a male, thirty-nine years old, an engineer. Two months previous to his death he consulted me, because of extreme pain in the mid-scapular region. This had developed gradually, following a fall from an aeroplane about one year before. Several months previous he had been seen by a noted neurologist, who had diagnosed arthritis deformans of the vertebræ. Examination showed a very slight angular kyphos corresponding to the third dorsal vertebra. There was muscle rigidity, a zone of hyperæsthesia corresponding to the level of the kyphos, exaggerated reflexes, and hyperæsthesia of the left side below the level of the third dorsal vertebra. The X-ray showed a destructive process involving the second, third and fourth dorsal vertebræ. There were no evidences of abnormality of the ribs. The temperature ranged from 100-101°. Tuberculin test gave a positive reaction. Although a differential diagnosis between tuberculosis and malignant disease of the vertebræ could not

¹ "The Growth of Bone," Glasgow, 1912.

FURTHER STUDIES IN OSTEOGENESIS

be made, it seemed advisable to give the patient the benefit of the doubt and treat him as though he were suffering from Pott's disease. Accordingly, the typical Albee operation was performed. The tibial graft was made unusually long (22 cm.), so as to afford rigid fixation of all the diseased vertebræ. The operation itself was *uneventful*. Almost immediately, subsequent to it, the patient's pain was relieved. He said that he had not felt as comfortable in many months. Four weeks later, however, he began complaining of pain in the chest and in the right thigh. Examination showed a distinct thickening of the right femur several inches below the trochanter and some thickening of the eighth right rib. X-ray showed the presence of diffuse bony enlargements, sufficiently characteristic of malignant disease to leave no further room for doubt as to the diagnosis. The patient died two months subsequent to the operation with symptoms of intrathoracic pressure.

Permission for partial autopsy was obtained. The right femur and several of the ribs showed fusiform enlargements which microscopically were diagnosed as carcinoma. The graft was found firmly healed between the cleft spinous processes. It held the vertebræ rigid and effectively prevented the collapse of the softened bodies. Its macroscopic appearance was that of dense cortical bone. At three levels cross sections of the graft and the adjacent spinous processes were removed for microscopical study.

The microscopical findings can be best summarized by a series of illustrations: Fig. 1 is a general view of the graft and the two halves of the cleft spinous process. The periosteal surface of the graft lies toward the right side of the picture. One-half of the spinous process is in intimate contact with the graft. The other, the fractured portion of the spinous process, is separated from it by a small gap.

Fig. 2 is taken from the tip of the graft, where it projects into the soft parts. Everywhere there are evidences of bone absorption. The surface of the bone, originally smooth, has been eaten away, evidently by the ingrowth of the capillaries which are everywhere present in great numbers. All the bone cells are empty. There are no evidences of new bone formation, either from the cells of the Haversian canals or from the bone cells.

Figs. 3 and 4 are high-power views of the same area. Fig. 3 is taken from a deep portion, showing the Haversian canals full of cell detritus and a few leucocytes. Fig. 4, taken nearer the surface, shows the ingrowth of capillaries into the Haversian canals. In both pictures there is complete absence of bone regeneration.

Fig. 5, taken from that portion of the graft in contact with the cleft spinous process, shows a different picture. On the surface of the graft is a layer of young, newly formed bone, sharply differentiated from the old bone of the graft. Within the Haversian canals are seen numerous capillaries, and surrounding the canals are small areas of new formed bone. These histological facts are better illustrated in Fig. 6, an enlarged view of the preceding. It is evident at a glance that the bone cells of the graft have entirely disappeared; the lacunæ are empty. Within the enlarged Haversian canals are seen cells closely resembling the typical osteoblasts found in young, growing bone, arranged concentric to the wall of the canal with almost the exactitude of a military formation. The new-formed bone is distinguished from the original bone of the graft by a marked difference in staining quality as well as by the presence of the sharply stained bone nuclei.

From the evidence thus far presented, there seems to be no question that the graft has acted merely as a scaffolding. The bone cells of the graft have shown no activity whatever and osteogenesis has occurred only where the graft is in contact with the living bone of the spinous process. The production of new bone around the Haversian canals is logically due to the immigration of osteoblasts accompanying the ingrowth of capillaries, since on the surface of the graft, where these osteoblasts are not present, bone destruction instead of new bone formation has occurred. In the next illustration, however, evidence will be presented to show that the bone graft itself with its periosteum contributes to the osteogenesis.

Fig. 7 is taken from the periosteal surface of the graft at a point where there is no contact with the spinous process. There is evidently new bone formation along the surface of the graft, and with the high power typical osteoblastic cells are visible, ranged along the surface of the bone. Within the Haversian canals a few osteoblasts are seen and small areas of newly formed osseous tissue.

Fig. 8 shows a still greater degree of periosteal activity. This is taken from a portion of the graft near the preceding section. Here the periosteal cells have proliferated with great rapidity, as evidenced by numerous mitotic figures, and resemble young cartilage cells, such as are seen in the early stages of callus formation. There is a distinct layer of new-formed bone on the surface of the graft. These two figures speak emphatically for the activity of the transplanted periosteal cells.

In Fig. 9, which is derived from the cancellous portion of the graft, it is clear that although most of the bone lacunæ are empty, there are numerous sharply stained bone nuclei which microscopically have all the characteristics of living bone cells. It must, therefore, be assumed that some at least of the bone cells do not die subsequent to the transplantation. In other words, the graft does not act entirely as a lifeless substance, as the first sections would seem to indicate. This illustration, although showing only a small portion of the bone, is typical of all the cancellous tissue of the transplant.

The method by which the newly formed bone gradually replaces that portion of the graft which has died, has given rise to much speculation. Axhausen holds that the old bone is first eaten away by osteoclasts and is then replaced by the activity of osteoblasts. Marchand, on the other hand, insists that this process is not a satisfactory explanation and that part of the reconstruction is done by what he terms "the creeping method." In this, there is a gradual progression of new formed bone into the old, the osteoblasts acting not only to produce the new bone, but also to absorb the old. Fig. 10 is suggestive of the method by means of which the old bone is replaced by the new. It shows a portion of the graft which has already been partly replaced by new formed bone. Most of the original lacunæ are empty, but near the new formed bone are seen two lacunæ which, although within the lighter stained area characteristic of the old graft, contain sharply stained large bone nuclei. These nuclei are quite different in appearance from those seen in the previous section—survivors of the original bone. These nuclei are larger, more lightly stained and contain a distinct chromatin network. They look exactly like the young nuclei of the new-formed bone. It is also to be observed that the canaliculi connecting the lacunæ with the new-formed bone show up very sharply. It seems a plausible theory to assume that these young bone cells have passed into the empty lacunæ through the patent canaliculi.

Summarizing these microscopical pictures, we see that neither the scaffolding theory, nor the opposing view is entirely correct, but that a double process is at work; to a certain extent the graft acts as a scaffold for the ingrowth of osteoblasts derived from the adjacent bone, but it also contributes to its own life, first by the persistence of bone cells, second by the activity of the transplanted periosteum.

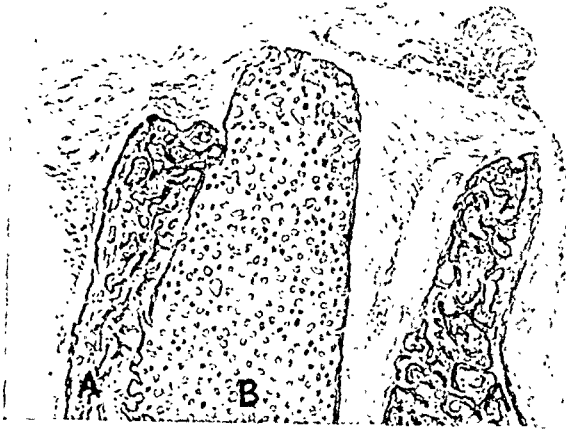


FIG. 1.—Low power view of bone graft and the cleft spinous process (first case). Note that one half of the spinous process is in intimate contact with the graft, that the other half is slightly separated from it. The right side of the graft corresponds to its periosteal surface. A, fractured spinous process; B, graft.



FIG. 2.—A portion of the graft near the tip where it projects into the soft parts (first case). Leitz, Obj. 1. oc. 4. Note the absorption of bone due to the ingrowth of capillaries. A, graft surface showing absorption; B, connective tissue.

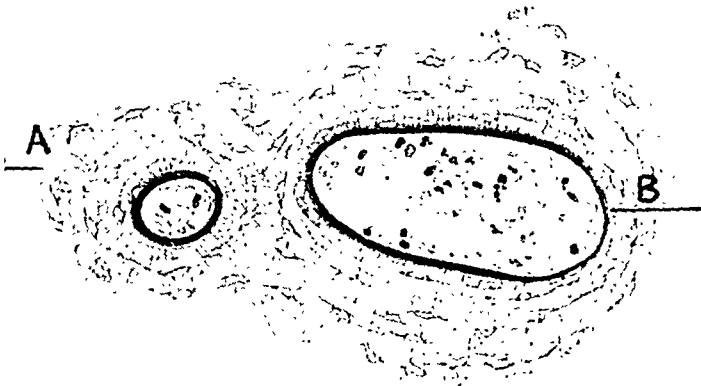


FIG. 3.—A portion of the graft near its centre (first case). Leitz, Obj. 5. oc. 1. Note that the lacunæ are empty and that the Haversian canals are filled with detritus. A, graft with empty lacunæ; B, Haversian canal with cell detritus.

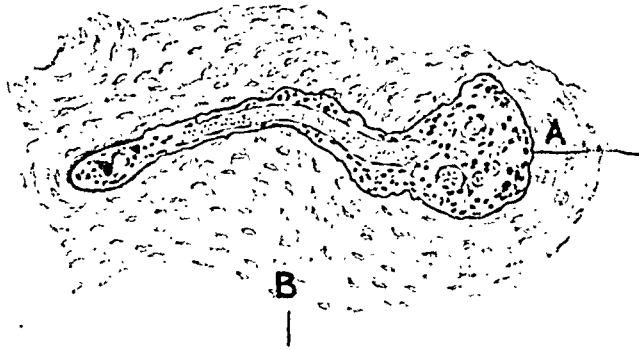


FIG. 4.—A portion of graft near the surface (first case). Leitz, Obj. 3. oc. 4. Note that the Haversian canal contains numerous capillaries, but that there are no evidences of new bone formation. A, enlarged Haversian canal containing numerous capillaries; B, graft showing empty lacunæ.



FIG. 5.—The bone graft, where it is in contact with the cleft spinous process (first case). Leitz, Obj. 3. oc. 4. Note that on the surface of the graft there is a layer of young bone differentiated from the graft by its color and by the sharply stained bone nuclei. A, bone lamellæ of spinous process; B, young newly formed bone on surface of graft in contact with fractured spinous process; C, young, newly formed bone about a Haversian canal.

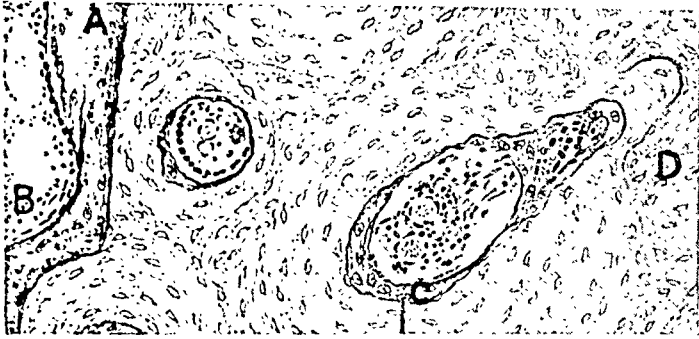


FIG. 6.—High power view of the preceding figure (first case). Leitz, Obj. 3. oc. 4. Note the formation of new bone about the Haversian canals, which contain in addition to capillaries, cells typically osteoblastic in the form and arrangement. *A*, young newly formed bone on surface of graft in contact with fractured spinous process. *B*, marrow cells of fractured spinous process. *C*, young, newly formed bone about a Haversian canal. *D*, dead bone of graft.

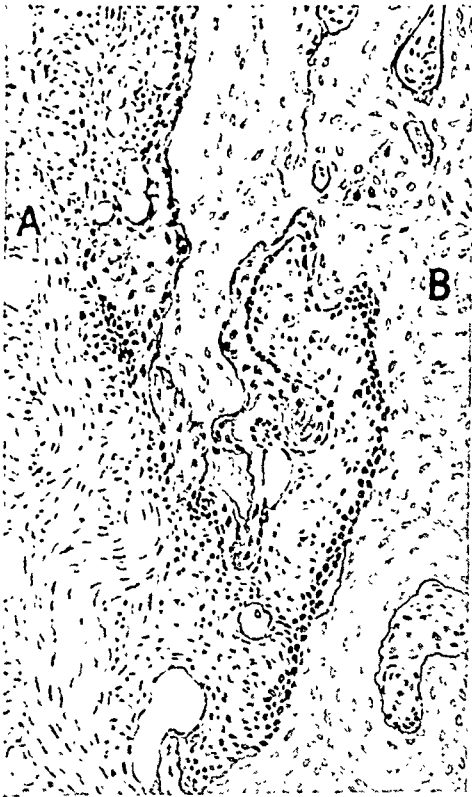


FIG. 7.—The periosteal surface of the graft (first case). Leitz, Obj. 3. oc. 4. Note the formation of new bone on the surface of the graft. This can only be due to the persistence of periosteal cells, since there is no contact with the cleft spinous process. *A*, connective tissue. *B*, graft (dead bone). *C*, young, newly formed bone on periosteal surface of graft.

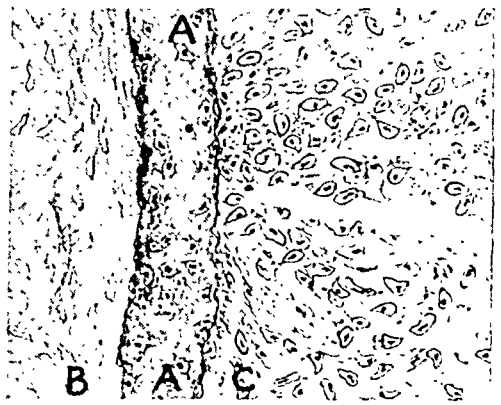


FIG. 8.—Another view of the periosteal surface of the graft (first case). Leitz, Obj. 5. oc. 6. This figure shows marked proliferation of periosteal cells with formation of young bone on the surface of the graft. *A*, newly formed bone on periosteal surface of graft (not in contact with fractured spinous process). *B*, graft showing empty lacunae. *C*, young cells cartilaginous in morphology and staining property.

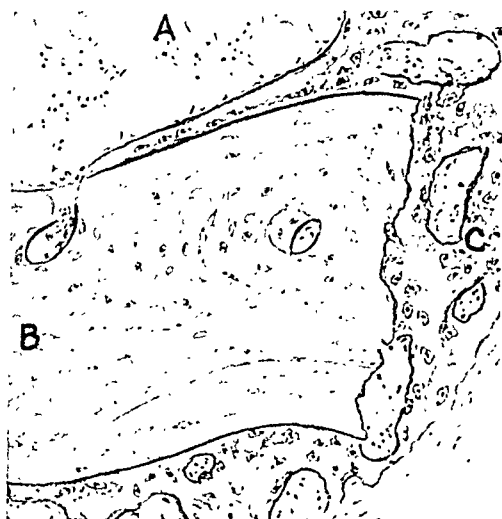


FIG. 9.—Cancellous bone of the graft (first case). Leitz, Obj. 3. oc. 4. Note the presence of numerous well-stained nuclei in the lacunæ of the graft. These cells microscopically gave all evidences of being alive, 60 days after transplantation of the bone. A, marrow of fractured spinous process. B, the graft showing numerous well-stained nuclei of bone cells. C, young bone on surface of graft.

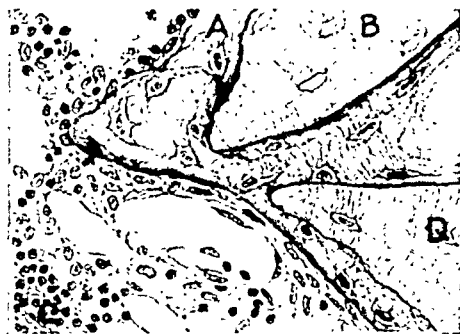


FIG. 10.—High power view of graft (first case). Leitz, Obj. 5. oc. 4. This view is suggestive of the process by which the dead bone of the graft is replaced by young living bone. A, newly formed bone on surface of graft. B, old bone of graft with empty lacunæ. C, marrow of fractured spinous process. D, old bone of graft with two well-stained nuclei of bone cells. Note the canaliculi extending from these lacunæ to the adjacent deposit of young bone. (See page 362.)

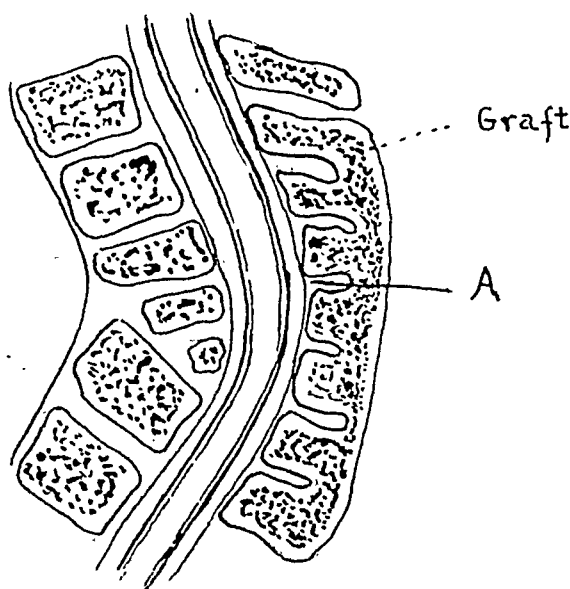


FIG. 11.—Diagrammatic sketch illustrating the appearance of the graft (second case) one and one-half years after implantation. Note the fusion of the spinous processes and the graft, so as to form a solid mass of bone. The level, A, indicates the site of the microscopical cross-sections illustrated in the two following figures.

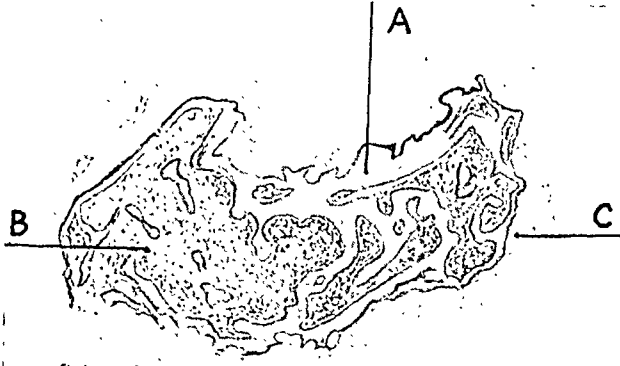


FIG. 12.—Low power view of the graft (second case) showing its conversion into a typical bone with marrow cavity, cancellous tissue and cortex. A, cortex; B, marrow; C, layer of tissue corresponding to periosteum.

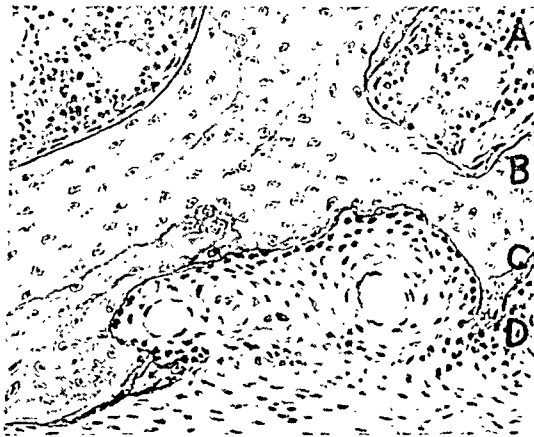


FIG. 13.—High power view of graft (second case). Leitz, Obj. 5. oc. o. The bone cannot be distinguished from the normal structure. The marrow cavity contains typical cells. On the surface of the bone are ranged cells which morphologically are identical with the osteoblasts seen on the surface of young growing bone. A, marrow; B, cortex; C, osteoblasts; D, fibrous layer of newly formed periosteum.

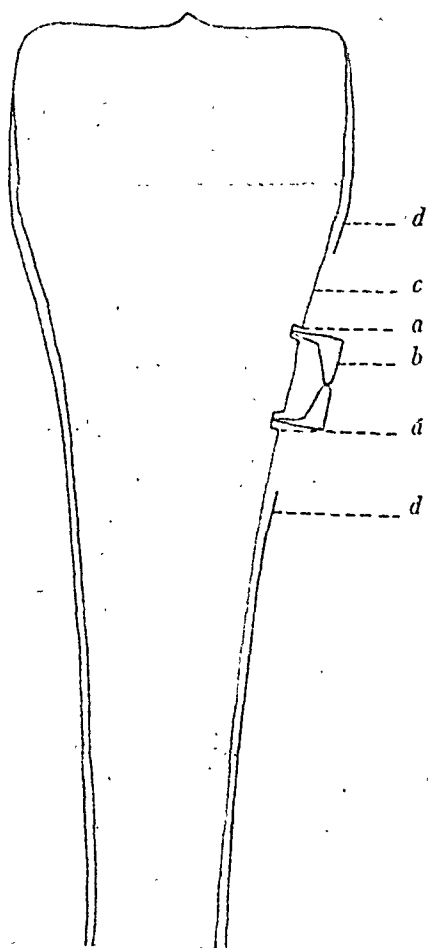


FIG. 14.—Diagram illustrating the principle of the cap experiment. *a*, groove in the surface of the tibia, into which the cap (*b*) has been implanted; *c*, surface of the bone bared of periosteum; *d*, the periosteum.

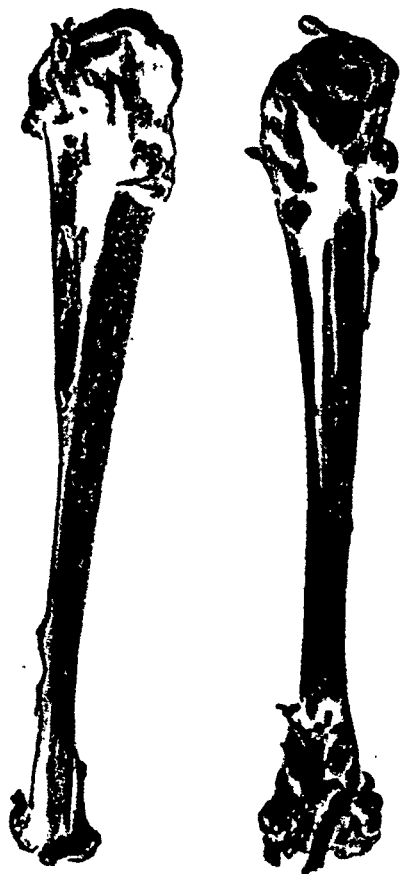


FIG. 15.—Photographs illustrating the method of attaching the caps to the surface of the tibia of a rabbit. On the left a glass cap, on the right one of steel.

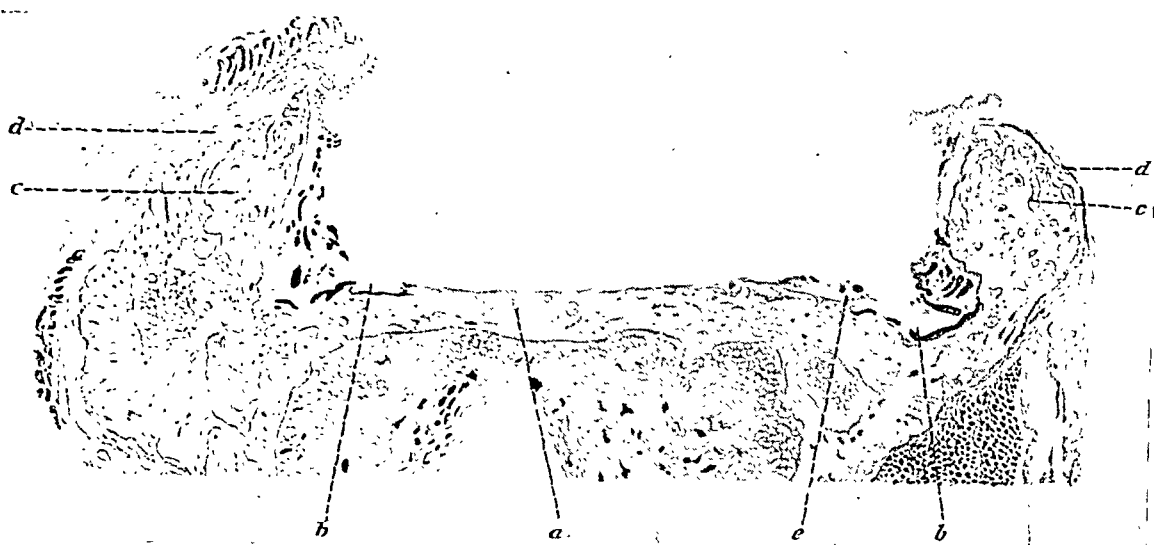


FIG. 16.—Camera lucida drawing of cross-section through the tibia, forty-eight days after implanting a steel cap. The cap effectively excluded the ingress of regenerated periosteum, therefore no new bone growth has occurred beneath the cap, whereas external to it, where the regenerated periosteum functionated, extensive new bone formation is seen. Leitz, Obj. 1. oc. o. Tube 140. *a*, Cortex beneath the cap; *b*, the groove in which the cap rested; *c*, new bone formation external to the cap; *d*, regenerated periosteum; *e*, blood clot. (From Mayer and Wehner. *Am. Jour. Orthop. Surg.*, Oct., 1914.)

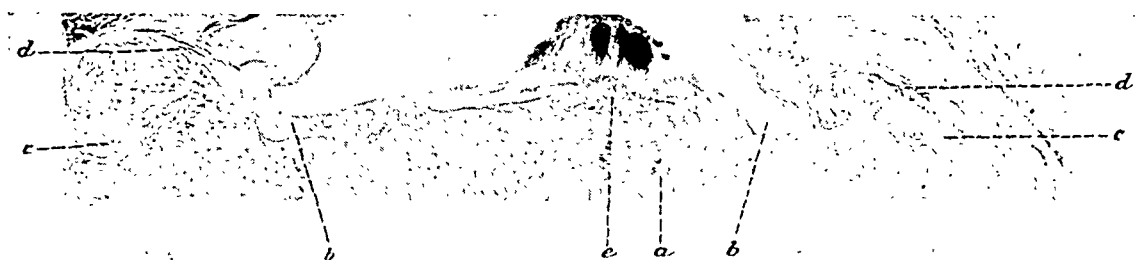


FIG. 17.—Camera lucida drawing of cross-section through the tibia fifteen days after implanting glass cap. The cap did not exclude the ingress of regenerated periosteum, therefore a new bone formation has occurred beneath it. Leitz, Obj. 1. oc. o. Tube 140. *a*, Cortex beneath the cap; *b*, the groove in the cortex showing on the left side the ingress of periosteum; *c*, new bone formation external to the cap; *d*, regenerated periosteum; *e*, trabeculae of new formed bone beneath the cap. (From Mayer and Wehner. *Am. Jour. Orthop. Surg.*, Oct., 1914.)

FURTHER STUDIES IN OSTEOGENESIS

The second specimen is derived from a case of Pott's disease in a child of nine. The typical Albee operation had been performed one and one-half years previous to the death of the patient. The child was at the time of operation in extremely poor condition; there were three discharging sinuses and a marked kyphos which had been present several years. The operation was withstood without shock, and for a time the general condition improved markedly. The sinuses, however, did not cease discharging, and there gradually developed symptoms of amyloid degeneration of the liver and kidneys, to which the death of the child was finally due. (This patient was the only one of a group of thirty in which the Albee operation failed to give an excellent result.)

At the autopsy the graft was found so firmly united to the spinous processes as to be indistinguishable from them. The sketch, Fig. 11, illustrates the macroscopic appearance of the spinous processes and the graft.

At two points sections of the graft were removed for microscopical study. A general view under low magnification is given in Fig. 12. A remarkable change in the appearance of the transplant is at once evident. Instead of a piece of solid cortex, such as was transplanted one and one-half years before, the graft has assumed the character of a tubular bone with marrow cavity, cancellous bone and cortex. In the high power view, Fig. 13, these facts are still more clearly illustrated. It is then evident that surrounding the bone there is a layer of tissue corresponding to the normal periosteum, and that on the surface of the bone are ranged numerous cells resembling the typical osteoblasts of young osseous tissue.

The cortex itself contains numerous well-stained bone nuclei lying in typical lacunæ and cannot be differentiated microscopically from normal bone. These two figures are a most interesting substantiation of Wolff's law of the functional adaptation of bone to changed mechanical conditions. The graft has assumed the peculiar form characteristic of all the long bones of the body. The specimen also gives an answer to the question so frequently put: whether the graft grows as the body increases in size. It certainly does, since it shows all the evidences of growing bone.

Although this paper deals essentially with these two autopsy specimens, it is helpful in this connection to call attention to a series of experiments performed by me during the winter of 1912.² In these studies, after preliminary transplantations of periosteum and subperiosteal resections, which seemed to prove the osteogenetic properties of the deeper periosteal layers, the following experiment was performed: The tibia of a rabbit or dog was stripped of periosteum over an area about one centimetre in diameter. The surface of the bone was scraped, so as to remove any adherent osteoblasts. A shallow circular groove was then bored with a trephine and into this groove a small cap of metal or glass was securely fastened (see Figs. 14 and 15). The idea was that, if, as Macewen claimed, the bone itself was responsible for osteogenesis, bone formation would occur beneath the cap; if, on the other hand, the periosteum was the vital bone producing element, bone would form on the outer surface of the cap but not beneath it. The experiment was performed on 23 animals. In more than half the cases, subsequent examination showed that minute gaps were present between the cap and the bone through which peri-

² Published in *The American Journal of Orthopedic Surgery*, Oct., 1914, and in *Archiv. f. Chirurgie*, Bd. 103, Hft. 3.

osteal cells had been able to pass. In nine specimens, however, the cap had effectually excluded all ingrowth. The duration of the experiments in these instances was 2, 5, 7, 7, 10, 32, 38, 48 and 55 days. "The microscopical picture was a striking negation of Macewen's thesis. The picture was always essentially the same, whether in young or old animal, dog or rabbit, with steel, nicked or glass cap. In every instance the surface of the bone remained bare, practically as it had been left at the time of the operation (see Fig. 16). Here and there a few fibroblasts derived from the Haversian canals were seen organizing the small blood clots due to post-operative oozing. But in none of the preparations was there an outpouring of osteoblasts, in none a particle of new-bone formation, or of any sign of activity on the part of the bone cells, such as mitoses or direct cell division. Outside the cap, however, where the periosteum had been allowed to regenerate, there was always a formation of new bone, most marked in young animals and in those where glass caps had been implanted. In these cases the new bone formation was at times so extensive as completely to imbed the cap. In those instances in which a gap, however small, had been present, there was invariably some bone formation beneath the cap. This could be traced, as indicated in Fig. 17, to periosteal cells which had crept in between the cap and the surface of the bone. Although it was not our intent to leave a gap of this kind, this type of experiment was of distinct value, in disproving the view that the foreign body had acted as a deterrent to osteogenesis. Further experiments emphasized the correctness of Ollier's teaching: that the most important osteogenetic cells are those lying between the outer fibrous layer of the periosteum and the surface of the bone—the so-called cambium layer of the periosteum. The osteogenesis observed in cases of bone transplantation, macroscopically without periosteum, is unquestionably due to the adhesion of these osteogenetic cells to the surface of the graft. Endosteal cells of the marrow cavity and of the Haversian canals are also capable of osteogenesis, though to a diminished degree."

SUMMARY

Study of two specimens recovered at autopsy, together with extensive animal experimentation, show that the fully developed bone cell has no power of division and that bone growth results from the activity of cells lying between the bone and the outer layer of the periosteum. The cap experiments prove that, when these cells are removed, the bone itself is not capable of reproducing them, but that the periosteum has that power. In transplantations, the bone graft acts partly as a scaffolding for the ingrowth of osteogenetic cells, but it contributes also to its own life, first by the persistence of some of its bone cells, second by the activity of the transplanted periosteum. The graft grows in its new situation and becomes modified in its form according to the changed mechanical conditions. (Wolff's law.)

FURTHER STUDIES IN OSTEOGENESIS

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LEO MAYER

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EFFACEMENT OF CAVITIES IN THE TREATMENT OF FRACTURES

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(Work of the War Demonstration Hospital of the Rockefeller Institute for Medical Research)

A "DEAD SPACE" between the tissues plays a very important part in infection. This has been very well demonstrated by the post-operative course. If during an operation a free space is left between two layers of tissue, this space will become filled with blood or serum. This hæmatoma, if the wound remains sterile, becomes encysted and is progressively reabsorbed. But, if a sufficient number of virulent bacteria have contaminated this cavity, suppuration transforms the hæmatoma into an abscess. It seems that these so evident facts have not been sufficiently emphasized, as a fundamental principle, in the surgical treatment of fractures. Cavities have been drained, but sufficient attention has not been paid in operating on infected fractures to efface the cavities formed by the displacement of the fragments.

Looking at the Fig. 1 representing a fracture of the femur with lateral displacement, the periosteum is seen very plainly bridging over each end, forming a more or less triangular cavity, formed on two sides by the bone surfaces and on the other by the periosteum.

These two cavities become filled with blood which soon will be infected and the infection in turn will disturb the formation of new bone and the cicatrization of the two ends progresses poorly. As Guillot and Woimant have shown,¹ in these cases of infection the extremity of the medullary canal does not become plugged and the vitality of the compact bone is diminished.

We have frequently controlled the truth of this assertion and there does not remain the least doubt in our minds of the necessity of removing at the operation all dead spaces, at least, when it is not possible to obtain this effacement of the cavities with more simple means as the external application of pressure on the soft parts of the limb in the region of the line of fracture. From this point of view Doctor Dehelly thought that the bridged plaster casts and the apparatus immobilizing in traction and suspension, such as the Thomas or the Blake splints, have the great drawback of not permitting the compression of the focus of fracture.

¹ Guillot and Woimant, *Surgery, Gynæcology and Obstetrics*, November, 1917; *Revue de chirurgie*, January-February, 1917.

Each time that after sterilization of a fracture of the femur we have used the Hennequin apparatus (Figs. 2, 3 and 4), we have obtained much better results. Here is an example already published in Doctor Dehelly's book with Carrel (Figs. 5 and 6).

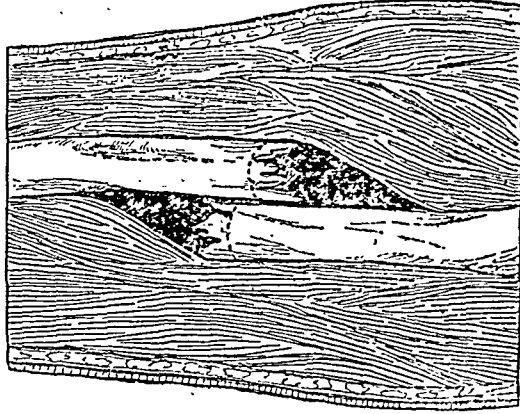


FIG. 1.—Fracture of femur with overriding fragments.

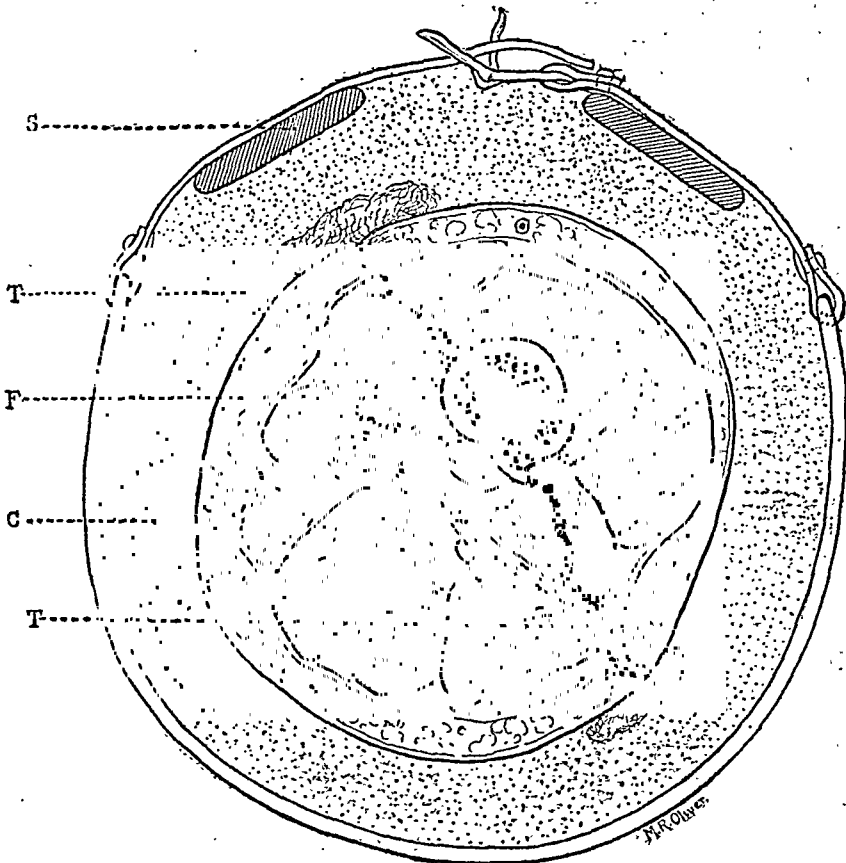


FIG. 3.—Hennequin apparatus applied loosely. Compound fracture of femur seen on section of the thigh. S, wooden splint; T, tract of wound (shell) after sterilization and secondary closure; F, focus of fracture with scattered fragments; C, surgical cotton pad, as cushion.

This case arrived at the hospital seven hours after having been struck by a shot which produced an extremely comminuted fracture of the left thigh.

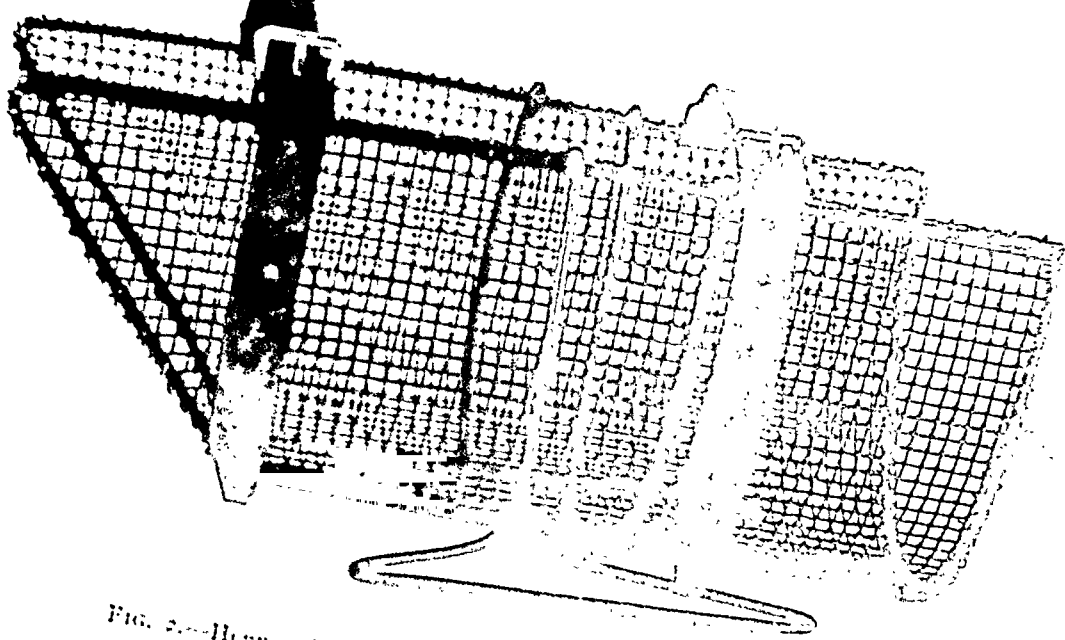


FIG. 2.—Hennequin apparatus for treatment of fractures of femur.



FIG. 5.—Comminuted fracture (fresh) of the middle third of femur, with bullet present.

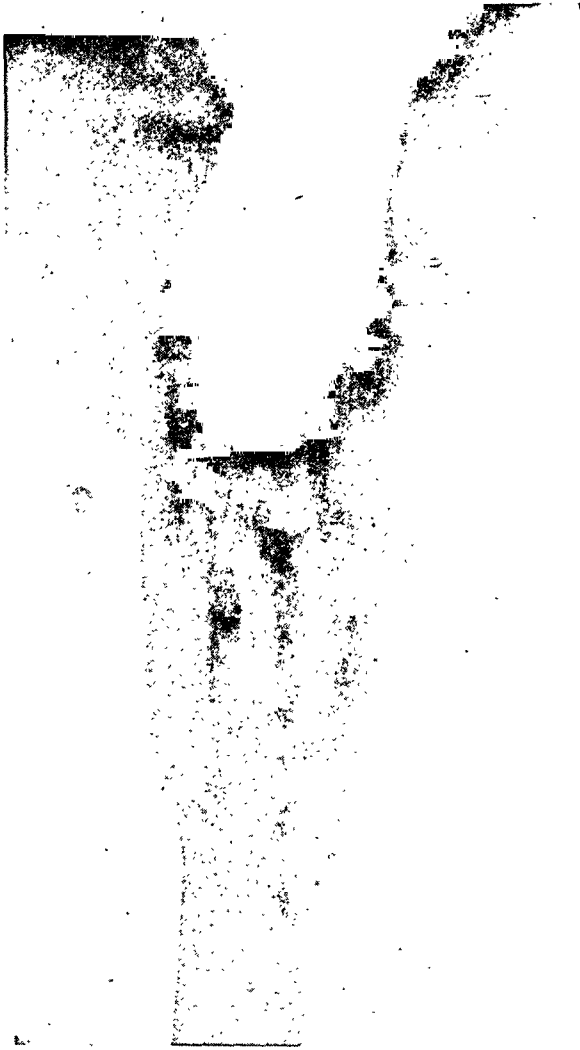


FIG. 6.—Only two small splinters removed. Good alinement with firm callus obtained by the use of compression of the focus of fracture with the Hennequin apparatus.

EFFACING CAVITIES IN TREATING FRACTURES

The diaphysis of the femur had been broken at the level of its middle third into multiple fragments. After cleansing of the contused soft parts two small splinters, completely free, were removed. The fifteenth day, after sterilization, the wound was closed. A good alignment with firm callus was obtained by the use of *compression of the focus of fracture with the Hennequin apparatus*. The fracture was firm on the forty-seventh day.

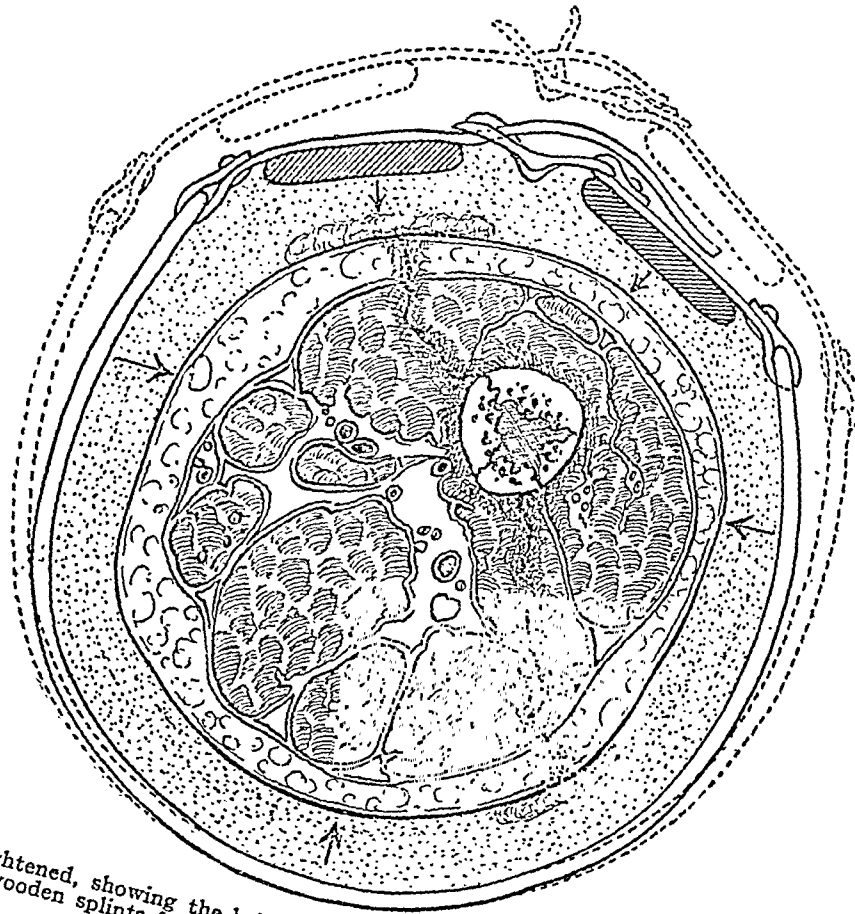


FIG. 4.—Apparatus tightened, showing the bringing together of the bone fragments by pressure of the apparatus. The wooden splints force down the upper fragment which usually tends to lift itself.

Before taking up in detail the different types of cavities which may be observed, let us state a few general rules of surgical technique:

1. The operation itself must not create a cavity in or near the bone.
2. Two overlapping fragments must not be cut perpendicularly to the axis of the bone (Fig. 1).
3. When a long bone is guttered not one but three sides must be removed (Figs. 7 and 8).

In the treatment of fractures several periods must be considered:

1. Immediately after the wound.
2. During the period of acute infection.
3. When consolidation has begun.
4. During the period of fistula.

1. *Immediately After the Wound.*—During the first intervention, the indication of an operative procedure on the bone is less imperative than later because the surgeon may hope and must count on the reduction of fracture by continuous extension with limb in good position; and we can state that very often, especially when external pressure was applied, these



FIG. 7.—Cross-section of thigh showing usual guttered femur (insufficient removal of bone).

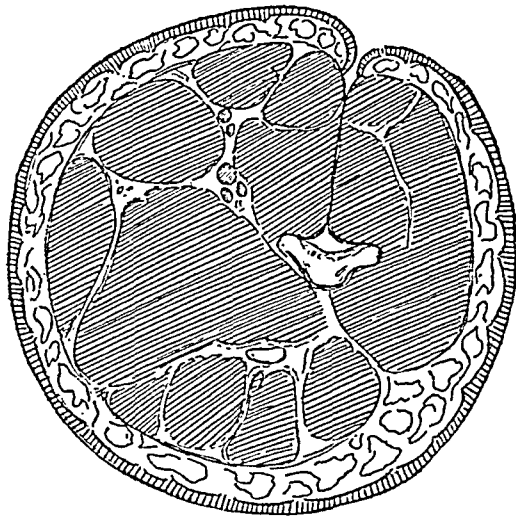


FIG. 8.—Cross-section of thigh—one quadrant remaining; proper removal of bone.

means alone are sufficient in bringing the fragments into their normal position and in effacing the cavities which separate them. However, there should be no hesitation in sacrificing the osseous wall which by its position tends to create a cavity with rigid wall when reduction is not obtainable. Here are some examples.

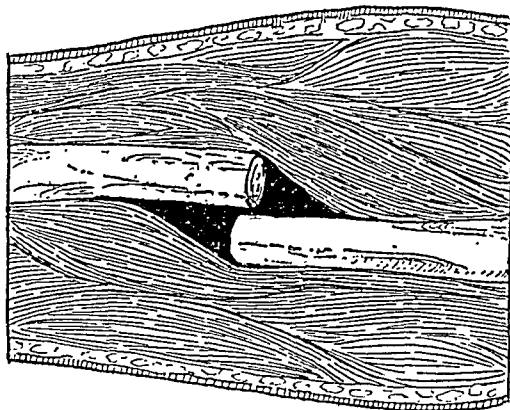


FIG. 9.—Fracture of femur unreduced—insufficient removal of bone.

(a) The loss of substance between the two fragments has left two ends cut nearly perpendicularly (Figs. 1 and 9)—between them a space persists which can be filled by a new bone only after a long time, and which cannot be effaced by the approximation of the periosteum and the soft parts. It is preferable to sacrifice one wall of the two fragments in

EFFACING CAVITIES IN TREATING FRACTURES

order to allow the apposition of the soft parts, care being taken of preserving the periosteum (Figs. 10 and 11).

(b) Long bevelled fragments form between them dead spaces of various shapes. In Fig. 12 two cavities are produced, the upper one triangular, the inferior one more elongated. This drawing was made from

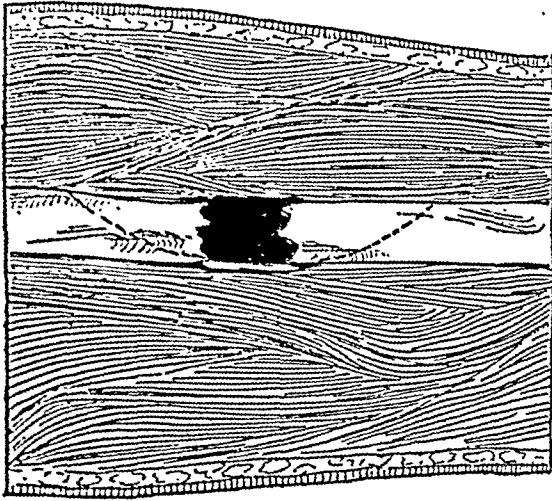


FIG. 10.—Transverse fracture; dotted line showing bone to be moved.

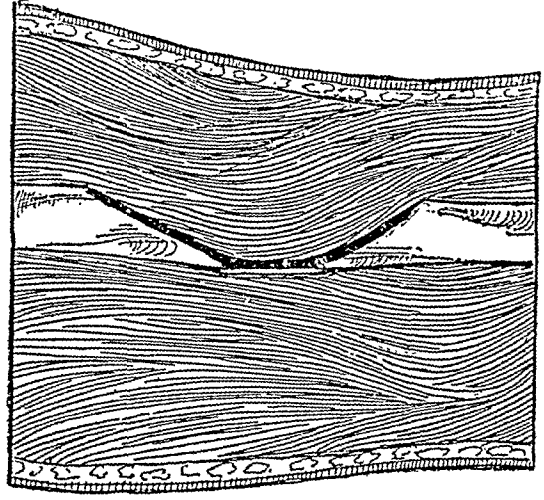


FIG. 11.—Same as Fig. 10, after operation.

an X-ray picture of a wounded soldier for whom two operations were necessary, one on each cavity, in order to obtain the cure. It was necessary to bevel the two extremities and to keep only the two parts of the extremities which were in contact (Figs. 13, 14 and 15).

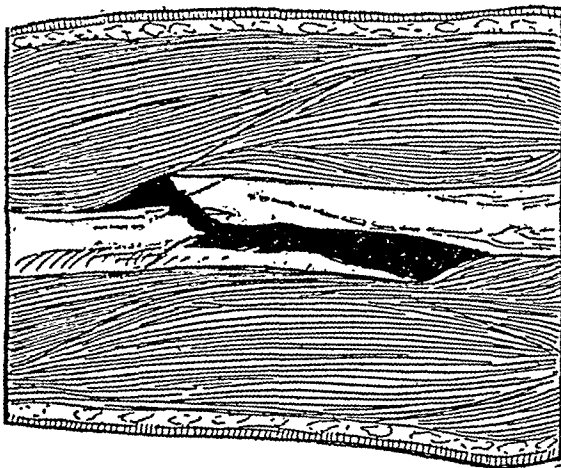


FIG. 12.—Long bevelled fracture of femur, dotted lines indicating projecting fragments of bone to be removed.

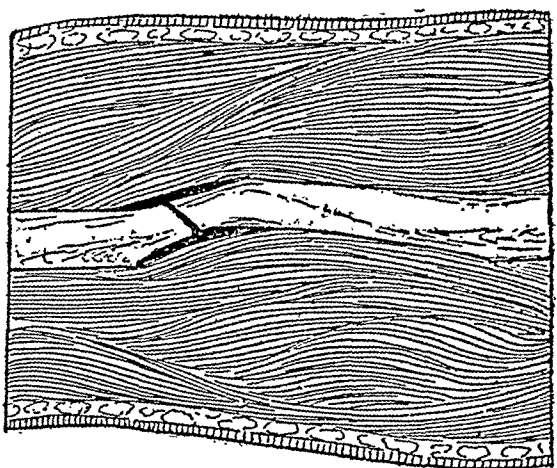


FIG. 13.—Same as Fig. 12, after operation, the soft parts filling the cavities.

(c) In this case we have two overlapping fragments of a transverse fracture (Fig. 9). The picture shows the two large cavities produced. If simple reduction is impossible the operation must consist in the removal of all the projected portion of the two fragments—only the points where the bones are in contact ought to be kept (Figs. 16 and 17).

2. *During the Period of Acute Infection.*—At the phlegmonous period it is more prudent not to treat these cavities in the manner described above. Above all they must not be ignored. They must at least be opened and instillating tubes must be inserted in order to carry out Carrel-Dakin method. This primary disinfection will place the tissues in more favorable condition for later adequate operation.

3. When consolidation has begun.

4. During the period of fistula.

The operation which we have recommended for the fresh fracture should be performed, but at these two periods when union has begun and during the period of fistula, care should be taken to preserve the points where the bone has united, because union occurs only where the bone is healthy.

One must not always reach the bone through the classical approach but sometimes it is better to reach it perhaps through the less accessible

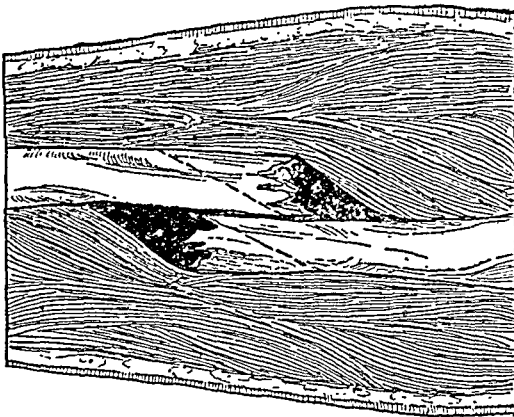


FIG. 16.—Overriding fracture of femur, showing the proper operation.

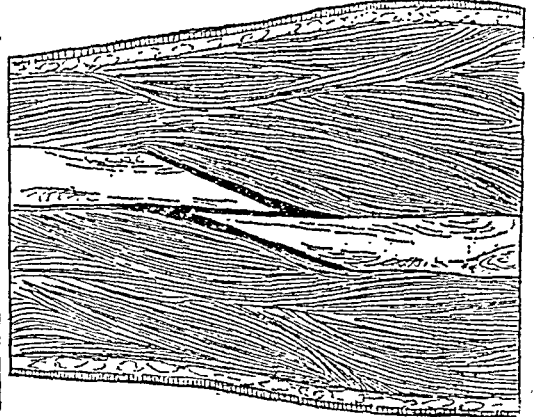


FIG. 17.—Same as Fig. 16, after operation.

aspect, but in such a manner as to attack the most pathological side of the fracture.

The following example illustrates this point:

A fracture of the tibia with a large loss of substance from the posterior aspect is united by a large anterior consolidating splinter. It is evidently important to keep the large anterior consolidating splinter and to "efface" the cavity by the resection of the posterior parts of the fragments on the posterior aspect of the tibia. In this case the incision must be made on the inner aspect of the leg, behind the inner border of the tibia, and it is easily seen that the new sloping cavity will be filled snugly by the soft parts of the posterior region of the leg (Figs. 18 and 19).

In the same manner, when after the first operation a new abscess develops, one must avoid, if the bone has been previously opened through the classical approach, operating through the same incision. It is most important that the most pathological side of the bone be reached with-

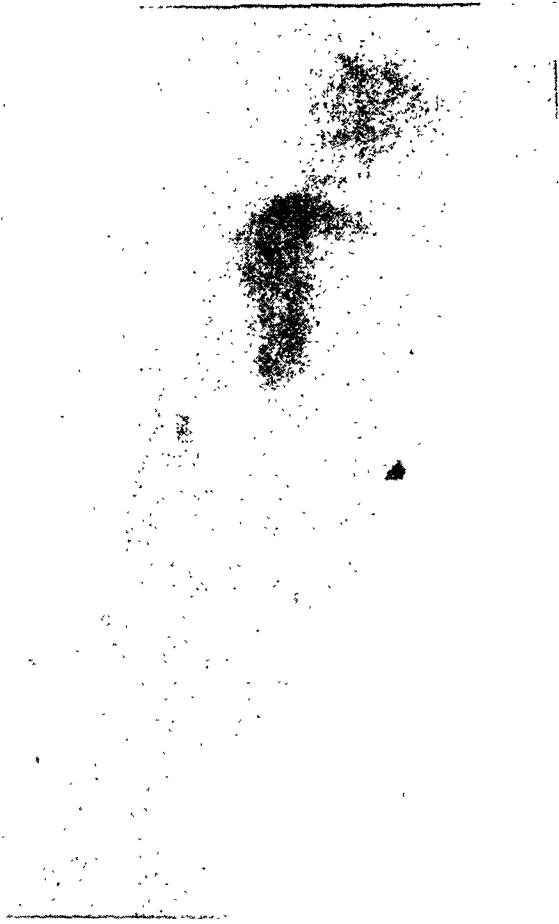


FIG. 18.—Compound comminuted fracture of the upper third of the tibia, with loss of bone tissue of the posterior aspect, creating a dead space.



FIG. 19.—Removal of the upper and posterior aspect of the lower fragment of the tibia, showing the sloping, cavity which can be filled in by soft parts.

EFFACING CAVITIES IN TREATING FRACTURES

out compromising the healthy parts indispensable for the solidity of the limb.

In doing this we have sufficient to spare because as we have already said it is enough to keep one of the sides of the osseous circumference. The thing to be avoided is to keep the infected side and this may happen if, before the operation, the localization of the pathological side has not been possible. In this case the bone is reached by the classical approach and the tendency is to remove the sides of the bone which are most accessible. This may be a mistake if the posterior quadrant is exactly the one which is the site of osteitis and which should be removed.

In the case, for instance, of a tibia which has been opened (Fig. 20) but which continues to suppurate because the posterior surface is the seat of osteitis, it is evident that in the operation one of the two surfaces, the internal or the external, must be conserved for the continuity of the bone; the quadrant of choice to be removed is that one which will allow



FIG. 20.—Usual insufficient operation on tibia, the lateral walls preventing apposition of soft parts.



FIG. 21.—Walls removed, allowing soft parts to approximate.

the soft parts to fill up the space most easily. In the case of the tibia it is better to keep the external side and to remove the internal, because when the external side is removed, the fibula prevents the soft parts from filling the dead space (Fig. 21), whereas there is nothing which prevents the internal tissues from coming in good position to obliterate the cavity after the internal side has been removed (Figs. 22, 23 and 24).

The cavity may be due to a peculiar formation of the callus—a fracture of the femur made by gunshot wound was united by a circular callus leaving a cavity with sequestra in the centre.

Three months after the wound was inflicted there was a sinus with large amount of discharge. An incision made through the old external wound down to the bone revealed a callus formed of two bridges of new bone, a large internal and a smaller external one. This cavity, so limited, communicated externally with a dead space in the external portion of

the thigh. The outer bridge of the callus was cut away with a chisel as were also the blunt ends of the upper and lower fragments. This allowed the whole cavity to collapse and the soft parts to come into apposition (Figs. 25 and 26).

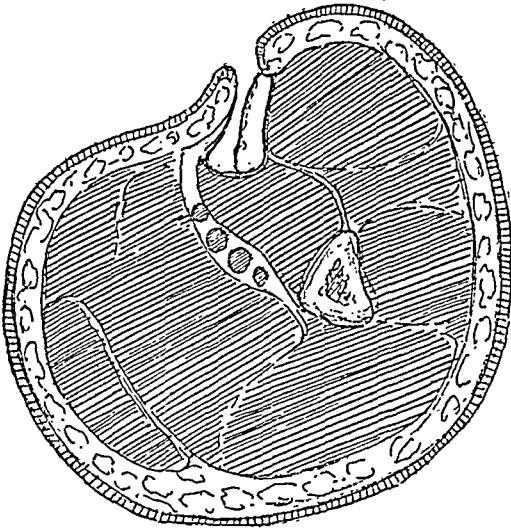


FIG. 22.—Removal of internal and posterior side of tibia through usual anterior incision, with incomplete approximation of skin.

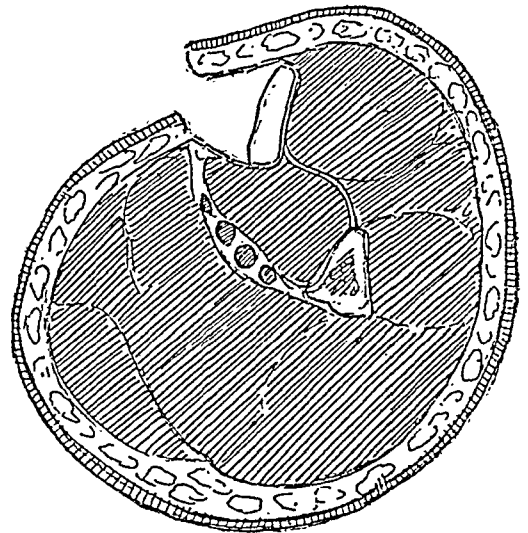


FIG. 23.—Proper incision.

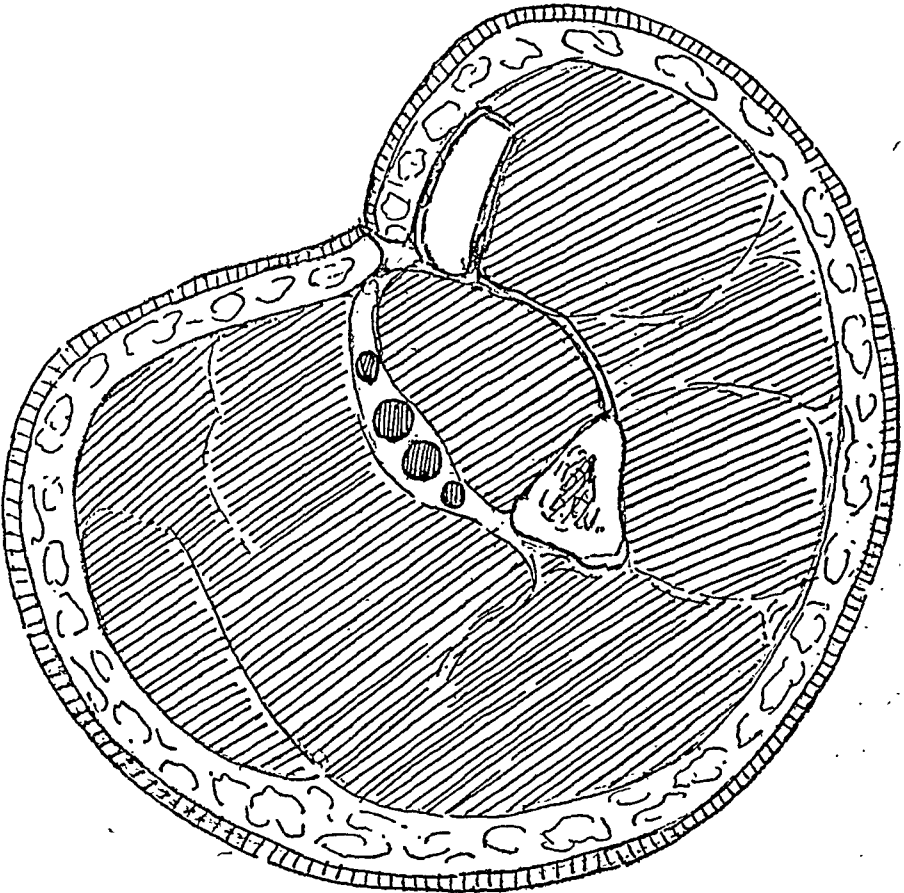


FIG. 24.—Same as Fig. 23, with obliteration of cavity by means of proper incision.

EFFACING CAVITIES IN TREATING FRACTURES

Interventions for the Purpose of Effacing Bone Cavities are not Necessarily Confined to the Bone.—There are cases (fracture near a joint) where it is impossible to bevel the cavities for fear of opening the joint. For instance, in a case of supramalleolar fracture of the tibia (Fig. 27), it was not possible to obliterate the cavity by plastic confined to the bone, but,

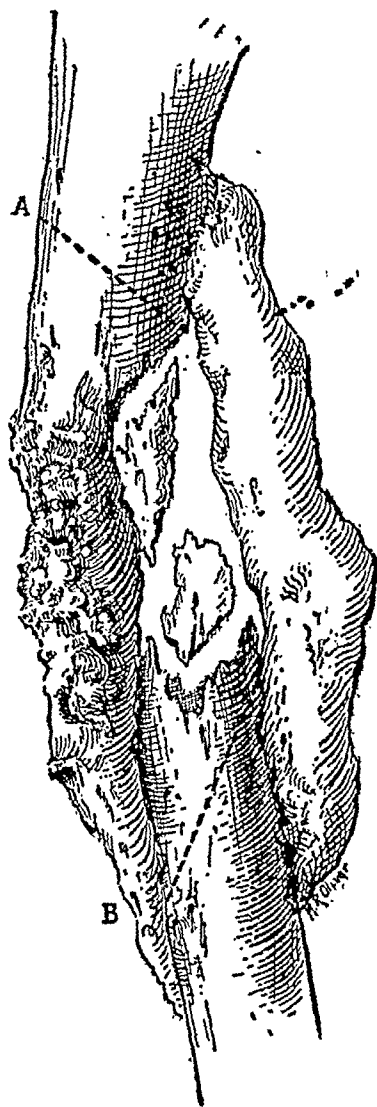


FIG. 25.—Fracture of femur, middle third, united by circular callus, showing cavity with two sequestra. Chronic fistula. A, B, extent of bone tissue removed.

after sterilization the cavity was obliterated with a pedunculated flap taken from the adjacent skin, with its underlying subcutaneous tissue being used to fill the cavity (Figs. 28, 29, 30 and 31).

In a case of fracture of the neck of the humerus with large loss of bone substance after union the cavity was satisfactorily filled with Beck's paste and closed with two layers, muscle and skin.² One may also in a simple but less elegant manner, slide into the bottom of the cavity a pedicle of skin and underlying subcutaneous tissue without suturing. Or, still, as we have done, shift one border of the wound with a bridge of

²This case has been published in "Treatment of Infected Wounds," Carrel and Dehelly, p. 203.

tissue, instead of a pedicle, and hold it in this shifted position by means of packing so as to place immediately on the front of the bone skin reinforced with its cellular tissue instead of allowing the epithelium simply to cicatrize (Figs. 32 and 33). This leads us to remark that the proper placing of the packing may contribute to the effacement of the dead spaces but that unfortunately they may also contribute to their formation.

In the two preceding cases of pedunculated flap and skin for the purpose of approximating it to the bony surface, it is necessary to obtain sterilization of the wound, and second, to maintain the flap in good posi-

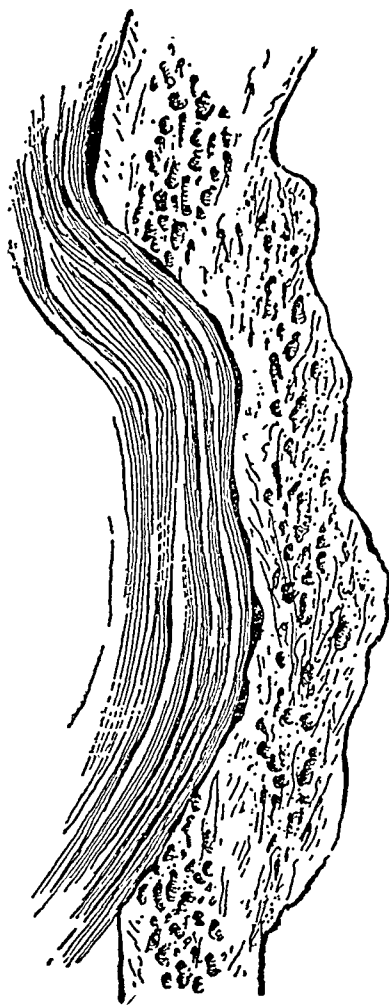


FIG. 26.—Schematic longitudinal section of the same with bone tissue removed and soft parts suppressing the cavity. Rapid healing.

tion with the proper dressing. In these cases, it is advantageous to apply elastic traction lacing for two days previous to the operation. This allows the shifting of the skin at the time of operation. Sometimes if the operation has been done in an aseptic wound and the effacement of the cavity practised, the wound can be closed and the compression made immediately.

The preceding case is one which was due to the dressing. The opera-



FIG. 27.—Old fracture of the lower third of the leg. Large callus and a bone cavity in the tibia which was] filled with adipose tissue.

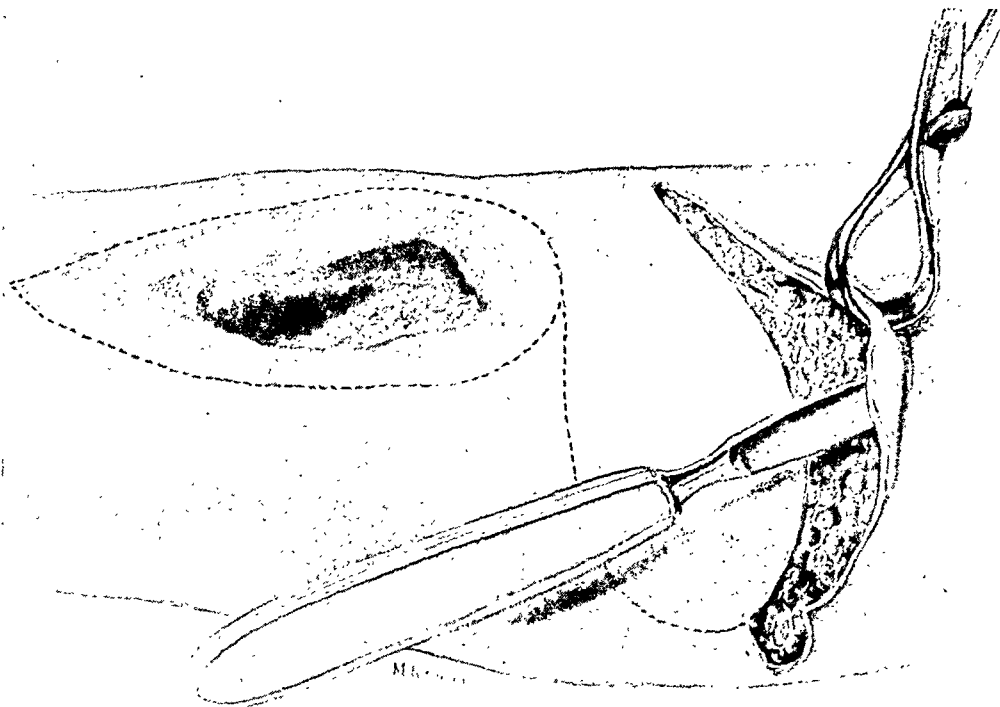


FIG. 28.—Skin flap with adipose tissue. The fat is removed subcutaneously by undermining the surrounding skin. Dotted line shows excision of scar and incision for skin flap.

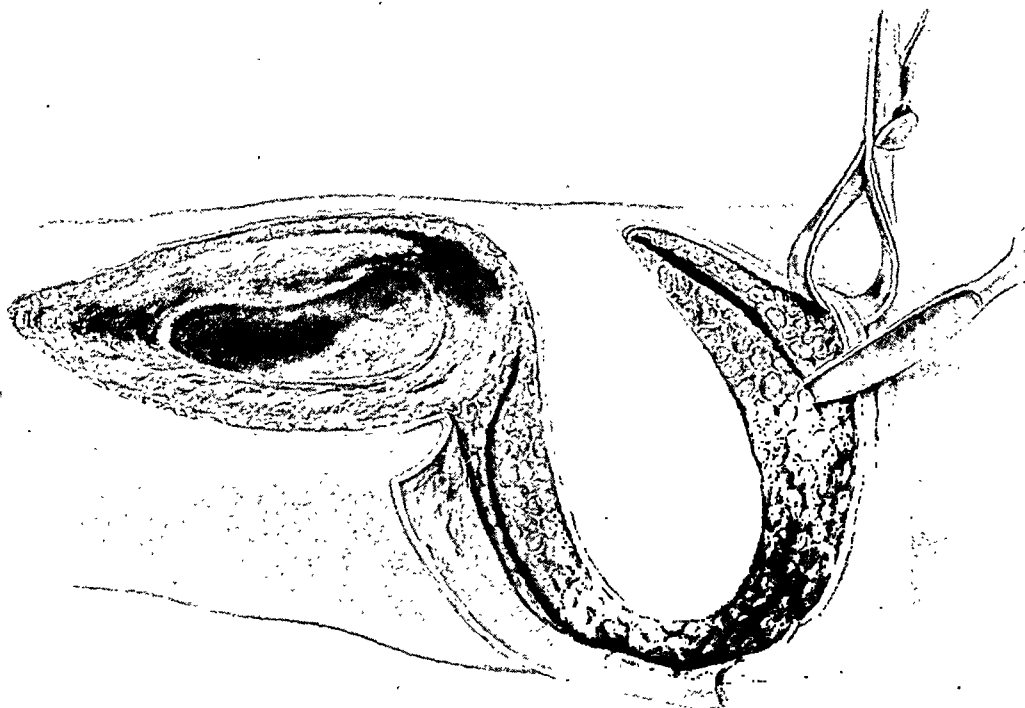


FIG. 29.—After undermining skin, fat flap is made by an incision to the aponeurosis, at some distance from the skin edge of flaps.



FIG. 30.—Flap turned, the fat filling the cavity.

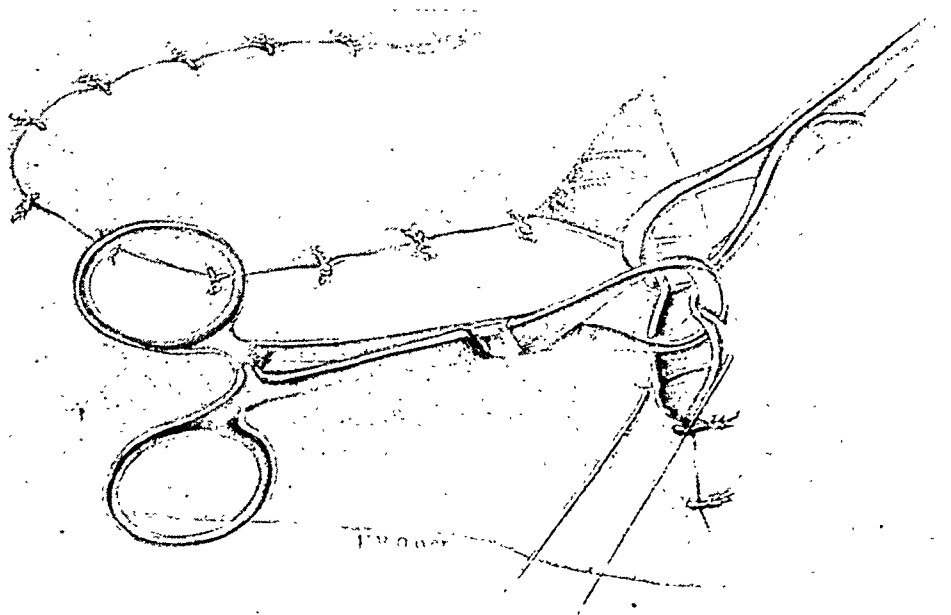


FIG. 31.—Closure with suture, leaving a small area uncovered, which will heal by granulation or with skin graft.



FIG. 34.—Compound fracture, middle third of leg. United chronic fistula; a narrow bridge of callus joins the two fragments. This bridge creates a cavity between it and the tibia, which space was responsible for the fistula.



FIG. 35.—Removal of the bridge of bone, suppression of the cavity by approximating the soft parts to the bone. Healing by first intention.

EFFACING CAVITIES IN TREATING FRACTURES



FIG. 32.—Fracture of tibia with loss of substance of skin.



FIG. 33.—Plastic operation—a bridge of skin and subcutaneous tissue shifted laterally to obliterate cavity.

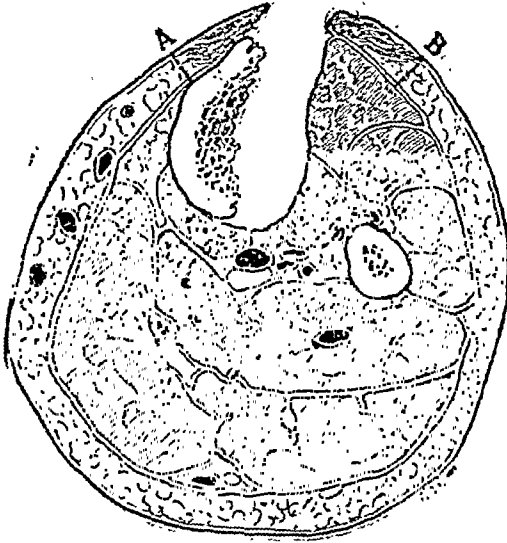


FIG. 36.—Stump of upper third of leg. Chronic fistula connected with a cavity on the outer and posterior aspect of the tibia. $X-Y$, cross-section through cavity; $A-B$, line of incision beyond scar tissue.

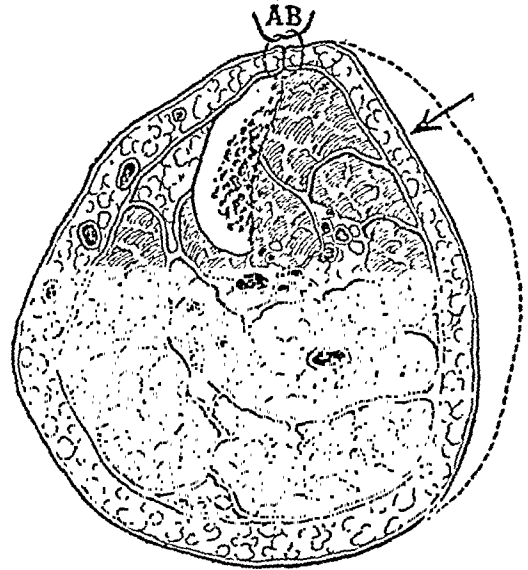


FIG. 37.—Removal of fibula, the soft parts suppressing the cavity. Healing by first intention. $X-Y$, cross-section through site of cavity, fibula removed, cavity suppressed by approximating soft parts; $A-B$, line of incision.

tion has been performed correctly, the cavity well bevelled, but the periosteum had been continuously separated by the packing. As a result a rigid walled cavity, which prevented the approximation of the soft parts, was formed (Fig. 34). In this case the final operation consisted in simply removing the bone from the external wall and in pressing the soft parts toward the tibia (Fig. 35). Healing was obtained by first intention.

An operation following the same principle was performed in a case with a short stump of the leg after a guillotine amputation through the middle third. Perfect result was obtained by Doctor Dehelly.

This patient arrived with a large granulating wound of the stump with bones exposed and a discharging sinus leading to a *cavity* due to the destruction of the external and posterior surfaces of the tibia. There was a choice between a disarticulation through the knee-joint or a plastic operation. After sterilization, with Doctor Carrel's method, the latter operation was performed.

First, the scar tissue was excised with the granulating surface and four centimetres of tibia were removed. The cavity of the external surface of the tibia was thoroughly curetted, and the fibula was entirely removed, which allowed the soft parts of the external aspect of the stump to fill the gap in the tibial bone (Figs. 36 and 37).

This removal of the fibula making the stump smaller in circumference, all skin edges could be approximated and sutured. Healing was obtained by primary union with a useful stump.

NOTE.—In similar cases with stumps of the leg, the removal of the fibula, which is not necessary for the solidity of the stump, seems to be advisable.

SYNTHETIC TRANSPLANTATION OF TISSUES TO FORM NEW FINGER

WITH RESTORED FUNCTION OF HAND

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AMONG the cases of war injuries under plastic treatment at U. S. Army General Hospital No. 3, the value of tissue grafting has been strikingly illustrated in two instances which are unique in the author's experience. In each case, severe laceration of the hand by high explosive shell and shrapnel had necessitated the immediate amputation of the four fingers with all, or the greater part, of the adjoining metacarpal bones. When the patients first came under observation, several months after injury, the stumps were healed and the thumbs were of normal strength and flexibility. All function as a hand had, however, been practically destroyed in each instance, since the thumb, the only remaining digit, had no power of prehension, in the absence of any opposing surface.

As an alternative to the fitting of artificial appliances, an entirely new digit was constructed by means of synthetic transplantation of tissues. This "finger" has provided in each instance the necessary opposition to the thumb, transforming the hither-to helpless stumps into useful members.

DESCRIPTION OF CASES

CASE I.—J. W., aged thirty years, sergeant, Co. K, 9th Infantry, A. E. F., sustained a severe shell wound of the left hand on June 11, 1918, at Château-Thierry. Amputation of the four fingers with the adjoining metacarpal bones was performed at the evacuation hospital where the last dressing was recorded on July 11, 1918. When admitted to U. S. Army General Hospital No. 3, on October 4, 1918, the stump was entirely healed and the thumb was of normal strength, with no contraction nor stiffness. The patient was, however, powerless to grasp and hold objects with the injured member, because of the lack of an opposing surface for contact with the thumb (see Fig. 1).

In the aim of a more complete restoration of function of the hand than could be obtained by a resort to artificial appliances, the construction of a new digit by tissue grafting was undertaken with the hearty coöperation of the patient. The first operation, by the Italian plastic method, was performed on December 27, 1918.

First Step.—After preparing the fields of operation with iodine technic, a rectangular skin flap, $2\frac{1}{2} \times 3$ inches, including full thickness of skin and subcutaneous tissue, was turned up from the right chest wall and sutured into the form of a finger. Its pedicle, the full width of the base, was left attached to the right side to supply nourishment to the boneless finger. The portion of chest wall left uncovered by the removal of the graft was closed by swinging plastic skin flaps, black

silk being used for suture material. (For operative steps, see Fig. 2.)

Second Step.—An incision was then made on the stump surface of the hand over the os magnum and extending down through the soft tissues nearly to the bone. To these soft parts was sewed the cuff of skin forming the boneless finger, great care being taken to secure exact approximation of corresponding layers of graft tissue to host tissue, *i.e.*, skin to skin and subcutaneous tissue to subcutaneous tissue. (It is as important to observe these relations in the transplantation of soft tissues as it is in the grafting of bone.) In order to avoid traction upon the boneless finger, the hand was then immobilized by means of incorporating the shoulder, arm and chest in a plaster-of-Paris spica, the axilla having first been thoroughly padded with cotton. The thumb was left projecting in order to determine the circulation of the limb (see Fig. 3).

Four weeks later, on January 24, 1919, the second operation was performed.

First Step.—After removing the case, the hand and boneless finger were disengaged from the thoracic wall by dissecting loose a circular flap of skin $1\frac{1}{2}$ inches in diameter, in addition to the finger portion.

Second Step.—The anterior internal surface of the upper portion of the left tibia was laid bare by a curved incision about five inches in length. A graft three inches long and about $\frac{3}{8}$ inch wide was mapped out with the scalpel in the periosteum, one end being cut wedge-shaped. Following the indicated pattern, saw-cuts were then made with the author's motor saw completely through the cortex to the marrow cavity. For purposes of "bone-seed," or increased osteogenesis, a sliver graft about $\frac{1}{8}$ -inch in diameter was removed from the side of the gutter formed by the removal of the first graft. Both grafts consisted of the full thickness of the periosteum, the cortex, the endosteum and as much of the marrow substance as could be obtained, *i.e.*, as much as clung to the graft when it was pried out of its bed. These grafts were then dropped into a normal saline solution of about 40° C., while the new bed of the graft was being prepared.

Third Step.—Now the boneless finger was tunneled by means of a small scalpel down to the os magnum. With an osteotome, a wedge-shaped mortise $\frac{3}{8}$ -inch deep was made in the distal-radial surface of this bone. The large graft was then taken from the salt solution and with a mallet its wedge end was driven into the mortise just made in the surface of the os magnum until it became firmly engaged in the cancellous structure of this bone. The sliver graft was thrust through the soft parts of the boneless finger along the ulnar side of graft No. 1, and, by means of the author's "bone-set," its end was affixed in the mortise already mentioned. (For position of the bone grafts, see radiogram, Fig. 4.) The end of the graft was then covered by means of the circular skin flap referred to above and sutured over to form the end of the new finger. The hand and finger were immobilized by means of a metal splint and left undisturbed for four weeks.

TRANSPLANTATION TO FORM NEW FINGER

Convalescence was uneventful, primary union taking place in all steps. In Fig. 5 is shown the new finger after the removal of the splint, four weeks after the implantation of the bone graft. The patient was now able to pick up sponges and towels with his thumb and grafted finger and an X-ray examination made at that time showed the transplanted parts firmly united to the bone of the hand (see radiogram, Fig. 4). With increasing strength and dexterity of the repaired hand, the patient has recovered his ability to perform the ordinary acts of every-day life, as is demonstrated in Figs. 6, 7 and 8. The helpless stump has been transformed into a useful member, capable of most of the necessary functions of a hand.

Aside from the favorable sequence of restored function, this case presents the personal history of a soldier in the U. S. Army of considerable interest. A native of Belgium, the patient was left an orphan at eleven years of age and was obliged to earn a living for himself. He spent an early life of varied occupations, serving as bell-boy, waiter, maître d'hôtel in Paris, interpreter in Switzerland and mail-carrier in Belgium. In 1913, he came to the United States (receiving citizenship here some time later) and worked as a day-laborer, boss of a railroad construction gang in the Canadian Northwest and later as fur-trapper. He had served in the infantry of the A. E. F. for a year and a half when he was injured while on duty at Château-Thierry.

Since his arrival at U. S. Army General Hospital No. 3, the patient has not only shown a remarkable coöperation in every effort made to improve his physical disability, but he has availed himself enthusiastically of the privileges offered at the hospital school, opportunities for study of which he was deprived in his earlier life. In spite of two operations, he has missed but five days of school during the period of his residence at the hospital and ranks first in scholarship and attendance among a total of 622 enrolled patient-students. At all hours of the day, when it is permitted to leave his ward, he is to be found at the school, where he is studying English and mathematics in the hope that eventually he may fit himself for some specialized work, such as surveying, or forestry, in which he is extremely interested, but which lack of training has thus far made impossible.

The case of this patient is illustrative of many convalescent cases at the hospital, in which careful advice as to future industrial occupation is being given and a preliminary instruction at the hospital school begun, with a view to a possible specialized training later under the auspices of the Federal Board for Vocational Education. In this case, the patient has been advised to take up forestry or engineering. During his convalescence he has made rapid progress in mathematics and English and allied subjects, all of which are building toward a future specialized training.

CASE II.—C. C., aged twenty-nine years, private, Co. D, 2nd Engineers, A. E. F., was struck by shrapnel causing severe laceration of the

right hand on June 13, 1918, at Château-Thierry. Amputation of the four fingers with the greater portion of the adjoining metacarpal bones was performed on the same day, the skin flaps being left open until July 15, 1918, when the wound was sutured and immediately healed by primary union. The patient was admitted to U. S. Army General Hospital No. 3 on October 4, 1918. In his case the indications for operative interference were the same as in Case No. 1. The strength and flexibility of the thumb were unimpaired, but in the absence of an opposing surface it had no power of prehension. In this case, however, it will be noted that the proximal heads of the metacarpals had not been destroyed. As shown in Fig. 9, the gap between the thumb and the amount of stump remaining was correspondingly less than in Case I. (Compare Fig. 1.) A shorter digit was required, therefore, in this case, to complete the stump surface and furnish the necessary contact with the thumb.

On December 24, 1918, the first operation in the construction of a new finger was performed. It was decided to obtain the bone graft from the left clavicle and the soft parts from the skin and subcutaneous tissues overlying.

First Step.—A rectangular flap of skin, 3 inches long and $2\frac{1}{2}$ inches wide, was turned up with the pedicle toward the left shoulder, exposing the middle third of the clavicle. With the author's motor saw an anterior portion of the clavicle, $2\frac{1}{4}$ inches in length and comprising about one-third of its diameter, was cut wedge-shaped at one end and so removed as to include the periosteum, the full thickness of the cortex and a considerable amount of marrow substance.

Second Step.—This graft was allowed to lie in the wound while an incision over the stump surface of the hand laid bare the distal end of the head of the metacarpal bone of the third digit in which a wedge-shaped mortise about $\frac{3}{8}$ -inch wide was made by means of an osteotome. The graft was then taken from its bed and with a mallet its wedge end was driven into the mortise just made. (For position of bone graft, see radiogram, Fig. 12.)

Third Step.—The rectangular skin flap with pedicle, turned back at the first incision, was then approximated in cuff shape about the graft and to the edges of the incision in the hand. The pedicle at its base was left attached to the neck to furnish nourishment to the graft tissues until circulation with the hand should be thoroughly established in the newly implanted parts. (For position of hand and grafted finger, see Fig. 10.) By plastic skin flaps the exposed surface of the clavicle was entirely covered, sutures of black silk being used. A generous cotton padding was then placed between the arm and the forearm and the chest wall. The hand was immobilized and undue tension upon the new finger was prevented by a plaster-of-Paris spica, as shown in Fig. 11.

On January 23, 1919, the plaster bandage was removed and the newly made finger and hand were disengaged from the neck in such manner as to leave an additional circular flap of skin about $1\frac{1}{4}$ inches in diameter at the end of the finger. This flap was later sutured so as to



FIG. 1.—(Case I.) Stump of left hand before plastic operation, showing complete loss of the four fingers and adjoining metacarpus. The left photograph shows the only remaining digit, the thumb, fully extended. On the right, the thumb is shown fully flexed. Note the absence of any opposing surface for contact with the thumb, as a result of which nothing can be grasped. To restore function of hand, the construction of a new digit was undertaken by means of synthetic transplantation of tissues (see Fig. 2).



FIG. 2.—(Case I.) Showing first operative step in tissue transplantation. A rectangular flap of skin and subcutaneous tissue was turned up from the chest wall and sutured into the form of a finger. Its end was approximated to the edges of an incision in the stump of the hand made over and down to the distal surface of the os magnum, by the Italian plastic method. A pedicle (indicated by arrow) was left attached to the chest wall to supply nourishment to the newly implanted parts until circulation with the hand should be thoroughly established. (This photograph was taken at the time of removal of the plaster-of-Paris spica in which hand, arm and shoulder were incorporated for four weeks following first operation.)



FIG. 3.—(Case I.) Showing immobilization of hand and arm in plaster-of-Paris shoulder spica to prevent traction on the new boneless finger. Note that the thumb was left projecting for purpose of determining circulation of the limb. This case was removed four weeks after operation and the finger was then cut loose from the chest wall. The second operative step, consisting in the implantation of the bone graft, is illustrated in the radiogram, Fig. 4.

FIG. 4.—(Case I.) Röntgenogram of left hand with grafted finger, showing implantation of the two tibial bone grafts. In this operative step, the boneless finger, cut loose from the chest wall, was first, tunneled by means of a scalpel and a wedge-shaped mortise was made in the distal-radial surface of the os magnum with an osteotome. Into this mortise a wedge-ended tibial graft, 3 inches long and about $\frac{3}{8}$ inch wide, was firmly driven, in the position shown in this figure. A sliver graft (indicated in illustration) was affixed along the ulnar side of graft No. 1, for purposes of "bone-seed," or increased osteogenesis. The skin was closed with interrupted silk sutures. This radiogram was taken four weeks after the transplantation of the tibial grafts which have now become firmly united to the bones of the hand. Note the amount of bony extremity originally absent in the hand and the resulting loss of function, to restore which the synthetic transplantation of tissues was undertaken.



FIG. 5.—(Case I.) Showing the grafted finger four weeks after the last operation. The lower photograph shows the thumb fully extended. In the upper view the thumb is flexed and in apposition with the new finger.



FIG. 6.—(Case I.) Showing new finger six weeks after the last operation. Note that the patient is now able to grasp and hold the pencil, which he is sharpening, between his thumb and grafted finger. By providing an opposing surface for contact with the thumb, the helpless stump shown in Fig. 1. has been converted into a useful member capable of performing most of the necessary functions of a hand, as is demonstrated in the photographs which follow.



FIG. 7.—(Case I.) The patient uses both hands in the natural manipulation of knife and fork.



FIG. 8.—(Case I.) This photograph shows the coöperation of the two members in an act requiring strength and dexterity.

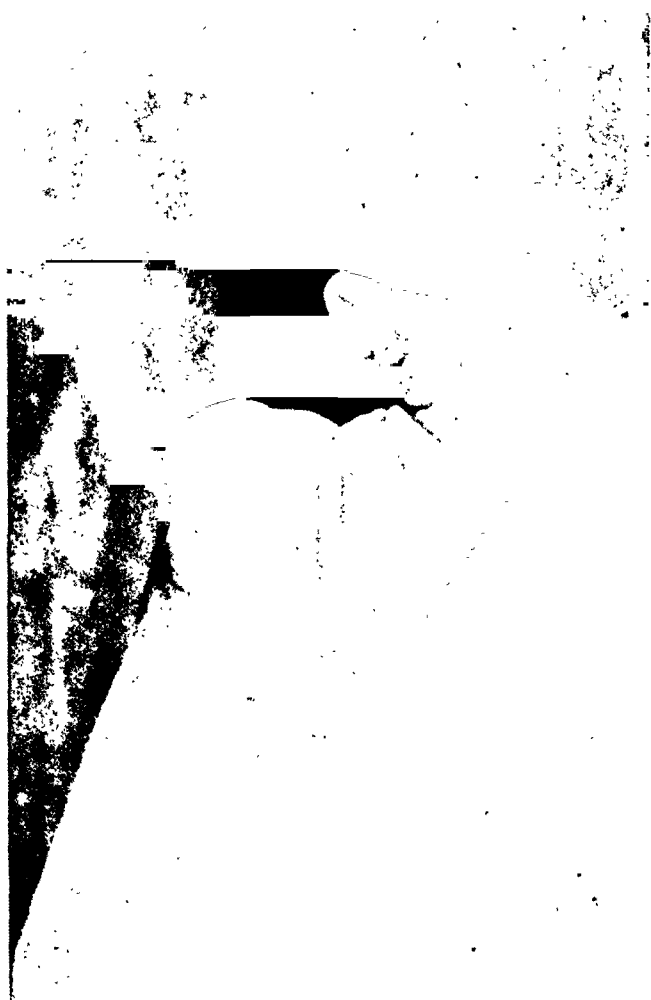


FIG. 9.—(Case II.) Showing stump of right hand, before plastic operation, with loss of the four fingers (and all but the proximal heads of the corresponding metacarpal bones). Note the gap between the stump surface and the thumb, when the latter is flexed as far as possible.



FIG. 10.—(Case II.) This photograph illustrates the method employed in this case of tissue transplantation, in which both bone and soft tissues were secured coincidentally from the clavicle and overlying parts. By means of a pedicle left attached to the body wall, supply of blood was furnished until circulation with the hand was established in the new finger. (This photograph was taken after the removal of the plaster-of-Paris case in which the arm and hand were immobilized for four weeks following the operation.)



FIG. 11.—(Case II.) Showing immobilization of forearm and hand in plaster-of-Paris spica to prevent undue tension on the grafted finger. This case was removed four weeks after operation. The finger was then disengaged from the neck with an additional flap of skin which was later sutured so as to form the end of the new digit and to complete the covering of the bone graft which had become firmly united to the bones of the hand, as shown in the radiogram, Fig. 12.

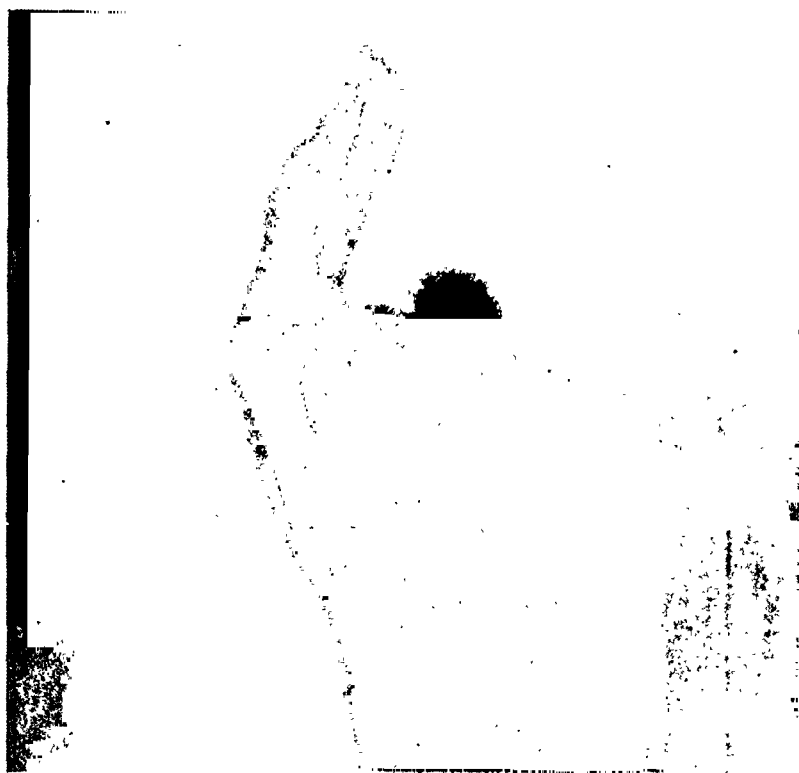


FIG. 12.—(Case II.) Röntgenogram of right hand and grafted finger, taken eight weeks after the implantation of bone and soft parts, which are now united to the tissues of the hand.

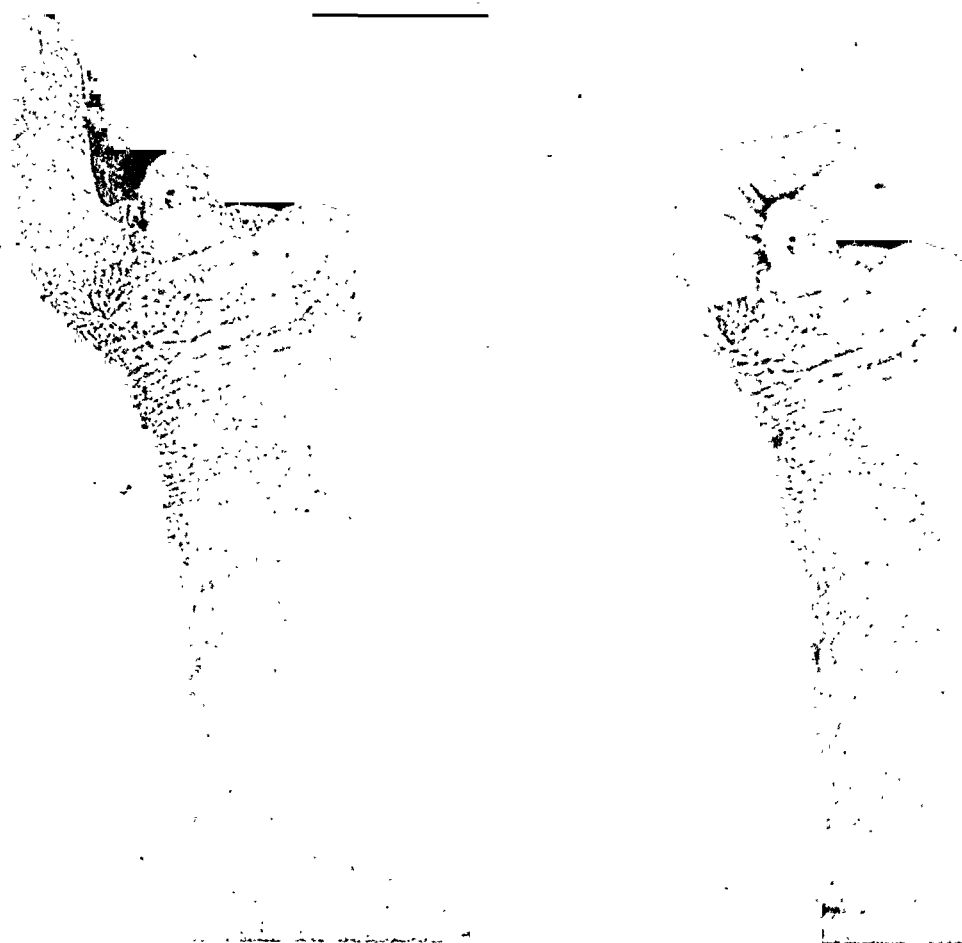


FIG. 13.—(Case II.) Showing the right hand with grafted finger, ten weeks after the implantation of soft parts and bone. On the left, the thumb is shown extended. The view on the right shows the thumb flexed and in apposition with the new finger.



FIG. 14.—(Case II.) This photograph, taken at the same time as Fig. 13, shows the patient holding a sponge between his thumb and new finger.

TRANSPLANTATION TO FORM NEW FINGER

form the end of the digit and to complete the covering of the graft which had become firmly united to the bones of the hand. In the radiogram, Fig. 12, taken four weeks after the removal of the plaster cast, the position of the tibial graft is demonstrated. Fig. 13 shows the right hand with grafted finger ten weeks after operation, at which time the patient was able to grasp and hold objects with his thumb and new finger, as shown in Fig. 14.

It is worthy of note in this case that at time of writing (March 21, 1919) sensation of touch has already progressed one-half inch in the new finger, showing that the nerve ends are actually regenerating in the grafted parts.

Discussion.—Of the two foregoing cases of tissue transplantation, the method employed in Case I is held to be the more satisfactory, not only in respect to technic, but because it affords greater freedom in choice of graft material and a more complete control of conditions favoring its growth. In this case, two independent operations were involved in the implantation of soft tissues and bone, respectively. Soft parts embodying the boneless finger were first transplanted from the thoracic wall and circulation with the hand was already well established in these tissues before the second operation, which consisted in the implantation of the bone graft from the tibia. In Case II, on the other hand, soft tissue and bone were taken coincidently from the clavicle and parts overlying, a procedure which involved the transplantation of two distinct graft tissues before the establishment of an adequate blood supply to the soft parts.

The utilization in Case I of the soft tissues of parts so accessible as the thoracic wall, or the abdomen, affords, in contrast to the foregoing method, a greater facility of technic. Moreover, the immobilization of the arm at a comfortable angle, permitted by this technic, is more conducive to normal circulation and to the ultimate establishment of blood supply in the newly grafted parts. This is an important preliminary step in the favorable sequence of bone transplantation. Into the tissues of the boneless finger, already well nourished, the transplants of bone were made in the second operative step, and their growth was thus assured.

Another advantage permitted by the method employed in Case I is the independent selection of graft tissue. Bone furnished, as in this case, by the tibia is nearly always preferable for grafting purposes, not only on account of its strength and its unusual osteogenetic activity, but also because this bone, by nature of its size and contour, offers a wide choice in the selection of graft material.

These cases emphasize the value and safety of extensive tissue grafting and demonstrate some of its possibilities in military plastic work.

NOTE.—Photographs by First Lieutenant A. J. Treichler, M.C., U. S. Army General Hospital No. 3, Colonia, N. J. Radiograms by First Lieutenant J. J. Sybenga, M.C., U. S. Army General Hospital No. 3, Colonia, N. J.

A NOTE ON EXPERIMENTAL CRANIOPLASTY

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THE operative procedures advocated for the repair of bony defects in the vault of the cranium, though finding a somewhat limited field for application in civil life, have recently been the subject of much interest owing to the great incidence of head injuries in modern warfare. The purposes of cranioplasty are not only to replace the natural protective structures of the brain but also to restore, for cosmetic reasons, the shape and appearance of the head. In attaining these objects, the material used should be of such a character that the inner surface of the skull, both during and after repair, be maintained as free from irregularities as possible. The practical problems involved in this type of surgery have, in recent years, been met by a direct application of the osteoplastic procedures employed elsewhere in the body; fresh transplants of fascia, cartilage, long bone, and scapula have been repeatedly used for plastic work on the cranium. None of these tissues is entirely satisfactory, however, for neither the fascia nor the cartilage offer much more protection to the brain than the scalp and underlying connective tissues. Furthermore, the lack of density in cartilage and fascia gives these materials, when compared to bone, a limited usefulness as a supporting framework for the scalp in restoring the convexity of the head. The objection to the employment of bone obtained from other parts of the body is twofold. First, the source of supply, aside from the scapula, is almost entirely limited to long bones from which the transplants are obtained in strips. But a cranial defect, owing both to the convexity to be restored and the area usually involved, does not easily lend itself for repair with such material, for in order to conform to the curve of the head such transplants must be bent and to fill a large defect the grafts must be broken up and pieced together. A second objection to the use of this type of bone graft is that cartilage is produced during the process of healing. The ideal material for repairing cranial defects would consist of plates of the cranial bones themselves, for from these, pieces which would conform to the convexity of the part needing repair could be selected and, by properly beveling the edges, the inlay could be inserted in such a way as to afford immediate protection to the brain. In addition, the absence of cartilage formation in the healing of this variety of bone is of great practical value, in that bulky masses are not produced at the edges of the graft where union between the old and new bone takes place. The difficulty encountered in the employment of such material for graft purposes is the supply. Autogenous transplants of this kind, unless the defects are small, can hardly be considered, and heterogenous fresh grafts

are quite difficult to obtain. This inconvenience may be overcome, however, by keeping on hand a supply of sterilized pieces of cranium which could easily be obtained during routine autopsies.

To determine the relative values of dead and live cranial bone when used as transplants, experiments were carried out on cats. In the first of these, a simple transfer was made of trephine buttons removed from the heads of two animals. In one the transfer was made immediately but in the other the button was kept in warm Ringer's solution for thirty minutes before implantation. Healing was *per primam* in both instances. After a period of three months the animals were sacrificed. Examination showed that complete bony union had taken place around the entire circumference of each of the buttons, but, of more importance, the transition from old to new bone on the inner surface was perfectly smooth and free of any exostoses (Figs. 3 and 4). Coronal sections of the skull through the graft (Fig. 6) showed that while the centre of the transplant was thin, the tables at the edges of the transplant were separated by a well-vascularized diploë of normal thickness.

A third experiment was made to ascertain how the outer table of the cranium would serve for graft purposes. In this case a single animal was used. After exposing the skull beneath the temporal muscle on both sides, the cranium on the right was partially penetrated with a trephine and the outer table was removed with a chisel. In doing so, owing to technical difficulties, part of the inner table in a small segment of the button was removed also, leaving a defect through the entire thickness of the bone. This defect was not repaired. On the left side, a trephine button was removed in the usual way and into the opening so produced was inserted the piece of outer table previously obtained. The fit was not exact so that part of the defect was left uncovered. The temporal muscle was replaced over the bone fragment and held it in position. Healing progressed satisfactorily and after three months the animal was sacrificed. Examination of the skull showed that both of the uncovered defects left at the time of operation were still present in the original size. The piece of outer table had become fairly fixed at all points where it came in direct contact with the edge of the trephine opening and the inner surface overlying the dura was smooth and free of all irregularities.

The final experiments were made with dead bone. In the first of these a trephine button was removed from a dead cat which had previously been embalmed with 10 per cent. formalin. After removal, the bone fragment was boiled for ten minutes in water and then inserted into a trephine opening of corresponding size in the skull of a normal cat. The animal was sacrificed after four months. Examination of the skull showed that repair had taken place as satisfactorily as in the cases in which fresh bone was used, and that the inner surface of the cranium over the former defect was quite as smooth as the surrounding areas. An experiment similar to this was carried out with the transplantation of a button obtained from a dead, embalmed cat; in this case the bone was subjected to sterilization in the autoclave at fifteen pounds pressure for half an hour. The animal in which this graft was placed

was observed for three months, when it was killed. Healing in this instance was in all respects the same as already noted in the other animals (Figs. 1 and 2). Coronal section of the skull through the graft (Fig. 5) showed, as in the experiments with living bone, that the centre of the implanted bone was thin, whereas the outer edge was of normal thickness. The diploë at the periphery was well vascularized and corresponded in appearance to that of the adjacent old bone.

These experiments are essentially similar to those made on dogs by Barth² in his original investigation on the healing of bone grafts. Barth concluded, from analysis of his experimental evidence, that dead and living bone, when used for transplantation purposes, behaved alike during the process of repair and that either could be used equally well as graft material. His statements precipitated a lengthy controversy concerning the relative osteoplastic value of bone when employed under various conditions; this controversy resulted, mainly in consequence of the demonstrations of Axhausen,¹ in a partial reaction by Barth, who finally admitted the superiority of living bone grafts over dead. During this controversy, however, most of the experimentation had been done with the view of determining the procedures to follow in repairing defects of the long bones and in correcting deformities of the spine. The problems encountered in these fields, however, are quite different from those which arise in relation to the repair of cranial defects and the experience gained by investigating one problem cannot be directly applied to the other; in fact, Barth's deductions regarding the healing of bone have been adversely criticized because he endeavored to apply his generalizations derived from experiments on the flat bones of the head to the problems of osseous healing in other parts of the skeleton.

For repairing defects in the long bones where early strength and union are of primary importance, a graft not only should serve as a bridge between the broken ends of bones but also should take an active part in the process of repair. In osteoplasty of this nature the question of cartilage formation is of great importance, for not only does this tissue act as a very efficient splint, but its presence is indispensable to the process of repair. The production of a large bulky callus at the points of union, therefore, is a condition to be welcomed rather than avoided and the displacement of surrounding tissue under such circumstances is but a temporary inconvenience. If, after the cartilage has been absorbed, there persist, in the neighborhood of repair, bony nodules or even if exostoses project into the muscular tissue, such osseous growths rarely cause trouble, and if they do, their removal subsequently is not difficult. The best material for grafting purposes in the long bones has proved to be live periosteum-covered bone, for the reasons that (1) it can be obtained readily from other parts of the patient's own body; (2) it takes an active part in the process of repair in that it early becomes vascularized and aids in the production of callus and subsequently of new bone, and (3) grafts of such tissue "take" in a higher percentage of cases than any other material tried. For bridging a gap between the ends of a fracture, dead bone can be used, and under proper conditions, it is conceded, a union



FIG. 1.—Exterior view of cat's skull into which there was implanted, three months previously, a sterilized button of bone. The button is shown in position. Bony union has taken place at the periphery and the button may be considered as a part of the cranium.



FIG. 2.—Interior view of same skull shown in Fig. 1. The implanted button, seen in the lower right hand corner, is hardly distinguishable from the surrounding bone. The transition from old to new bone is smooth.



FIG. 3.—Exterior view of a cat's skull into which was implanted three months previously a button of bone which had just been removed from another normal cat. Healing has been complete and the original defect has been completely restored.



FIG. 4.—Interior view of same skull shown in Fig. 3. The smooth healing, apparent in Fig. 2, is likewise present in this case. In both instances the grafts are held equally firm by new bone.



FIG. 5.—Coronal section through graft shown in Figs. 1 and 2. The position of the graft is indicated by the white lines. Note the thickness of the diploë at the periphery of the transplants and the even contour of the inner table of the skull over the points of union between graft and old bone.



FIG. 6.—Coronal section through graft shown in Figs. 3 and 4. The white lines indicate the position of the graft. The diploë at the periphery of the graft is of normal thickness and the contour of the inner table, as in Fig. 5, is even and smooth over the healed area of skull.

EXPERIMENTAL CRANIOPLASTY

will be formed between it and the bone to be repaired. But dead bone plays no active part in repair and when such material is used the chances of a "take" are somewhat less than they are with fresh tissue.

In the repair of cranial defects, a protective bridge is the essential requirement and the immediate need for a strong union is not so great as it is in other parts of the skeleton. By using a properly selected plate of cranial bones, a protection for the brain may be effectively obtained even before repair has advanced, provided only that the graft be properly beveled and inserted in such a way that pressure from without is transmitted to the edge of the defect. In this location, where the bones are immovable and muscular pull is hardly to be reckoned with, permanent fixation of grafts can be obtained by the use of pegs or similar appliances at the time of operation so that the formation of a cartilaginous splint to hold the fragments is not necessary. Neither is the presence of callus needed in the process of subsequent repair, for union between fractured bones of the cranium takes place directly between the opposing surfaces of the fragments in much the same manner that *per primam* healing proceeds after laceration of the integument. On the other hand, the formation of callus, which follows the use of living bone obtained from other parts of the body, is to be avoided, for the encroachment, even though temporary, by a mass of such material into the cranial cavity may do harm. Furthermore, as is well known, after the absorption of callus has been effected, there may be left osseous excrescences capable of causing in the central nervous system local irritations difficult to remedy. Live cranial bone may have an advantage in cranioplasty over dead bone in that the living tissue may be vascularized and replaced more quickly. But this time element is not as important in the skull as it is elsewhere, for so long as the requirements of protection to the brain and restoration of the shape of the head are fulfilled, replacements of the graft with new osseous tissue may proceed either quickly or slowly. This slight advantage on the part of living cranial bone, however, should be recognized in the selection of material and live grafts should be used when possible, but unfortunately, the opportunities for obtaining such tissues are few. The experiments on cats reported here indicate that well sterilized dead cranial bone forms a good substitute for the living, and, for the reasons given above, it should be used in preference to bone grafts obtained, even though fresh, from other parts of the body. It would hardly be justifiable though to conclude from these experiments on cats that the same procedures would be applicable to man, for in these small experimental animals the pieces of bone used were not analogous to those necessary for the repair of the human cranium. The reaction of a cat's tissue to a small piece of dead bone the size of a trephine button (2.5 cm.) may not be noticeable, whereas in man the larger bulk of foreign material represented by a plate of sterilized bone may possibly cause an entirely different reaction. Sicard,² however, has reported recently a series of eighty-five human cases in which cranioplasty was performed with plates of bone taken from the skulls of cadavers and he states that such plates of thoroughly sterilized bone are well tolerated by the tissues.

CONCLUSIONS

The problems of cranioplasty cannot be met entirely by the experience obtained from osteoplastic work on the long bones. The logical material to use in cranioplasty consists of plates of cranial bone, for (1) the requirements of protection for the brain and restoration of the shape of the head can be immediately accomplished; (2) the formation of cartilage, with possible resulting exostoses, is avoided. Animal experimentation (on cats) indicates that either living or dead grafts may be used effectively in the head. In man, living grafts are recommended, but if they are not available, plates of sterilized cranial bone are preferred to any other tissue.

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HYPERTONIC GUM ACACIA AND GLUCOSE IN THE TREATMENT OF SECONDARY TRAUMATIC SHOCK

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At the time this country was drawn into the world war the Committee on Physiology of the National Research Council decided to interest our physiologists in a coöperative investigation of surgical shock. Since then this laboratory has devoted all of its facilities and all of its research time to the study of that problem. One line of our experiments led us to the use of a strong solution of gum acacia and glucose in water in the treatment of shock. It is the purpose of the present paper to review briefly the experiments that led us up to that point,* and to present in detail the results, still quite limited, that have been obtained through the use of the solution in the treatment of shock and allied states in man.†

REVIEW OF EXPERIMENTS ON THE MECHANISM OF SHOCK

The first experiments done here were planned with the idea of familiarizing ourselves with the state that has been called shock by those who have worked on the subject, and of determining which manifestations of the state are fundamental to its development. These objects we hoped to attain by studying shock as produced in diverse ways. For, if it could be demonstrated that certain disturbances were constantly present there would be presumptive evidence that they were essential to the state of shock, and we would then be provided with a basis for the development of rational methods of treatment.

We believe we have succeeded in producing in the anæsthetized dog a condition resembling so-called secondary shock (*a*) by the usual method of exposing and manipulating the intestines;¹ also (*b*) by so occluding the inferior vena cava, between the diaphragm and the liver, as to hold the arterial pressure down to about 40 mm. Hg. for a period of about two hours;^{2, 3} (*c*) by occluding the thoracic aorta, distal to the origin of the left subclavian artery, so as to keep the arterial pressure beyond down to

* This phase of the work was begun in collaboration with my associates, Robert Gessell and Herbert S. Gasser, and was carried to completion by the latter and the author. Formal reports were submitted to the Committee as the work progressed and preliminary reports have been made before the Washington University Medical Society. It is being prepared for publication in full in the American Journal of Physiology.

† The results have been reported to the Committee and before the Washington University Medical Society. Doctor Gasser was prevented by war exigencies from participating in some of the preliminary experiments and in the clinical studies.

20-40 mm. Hg for a period of about two hours,³ and (*d*) by the continuous intravenous administration of adrenalin at such a rate as to maintain a high arterial pressure for a period of twenty or more minutes.^{4, 5} The symptoms eventually exhibited by animals exposed to these four forms of treatment are very similar; in all there is a characteristic apathy, usually with persistent eye reflexes, an inefficient circulation, as evidenced, when the condition is fully developed, by a low arterial pressure, a reduction in blood volume accompanied by concentration of the blood, and a reduction in reserve alkalinity. Furthermore, the pathological pictures, in certain respects, also are alike in all.

THE CIRCULATION IN SHOCK

In an effort to ascertain the *cause of failure of the circulation*, a study was made of (*a*) the arterial pressure, of the venous pressure, both (*b*) jugular (right auricular) and (*c*) portal, and of (*d*) the peripheral resistance.

A. Arterial Pressure.—The usual criterion of shock is a low arterial pressure. In the absence of this sign most laboratory workers, and perhaps clinicians, also, would not feel justified in making the diagnosis of shock. Yet, in agreement with Gesell⁶, we are of the opinion that, in animals, at least, the circulation may be markedly reduced before the arterial pressure begins to fall. Thus in experiments on caval shock, after de-occluding the inferior vena cava the arterial pressure rises for a time to mount as high as, often higher than, the normal initial level. Observations on over 200 instances of this kind of shock have shown that if the arterial pressure begins to fall consistently before two hours have elapsed after decompressing the cava, the fall continues (there has been but one exception) until the circulation completely fails. If, in such instances, the animal is not in shock at the time its arterial pressure is still high, it at least seems justifiable to assert that shock is then developing. One of our cases of shock in man, as will be seen, possibly belongs to this category.

B. The jugular pressure is supposed to be an index of the effectiveness with which the heart pumps on the blood that is returned to it. We have been impressed, however, by the uncertainty of this method of judging the efficiency of the heart. However this may be, it can be asserted that in none of the types of shock we have studied has there been any material increase in jugular pressure, and yet we are convinced that in shock the heart may not preserve its normal efficiency. While it is true that against the extreme constriction produced by a large dose of adrenalin, or against a closed aorta, the heart in shock often is capable of raising the arterial pressure quite as high as can the heart of normal animals,⁶ yet we have obtained evidence indicating that the shocked heart may be incapable of such sustained efforts as is the normal heart.

C. The portal venous pressure during shock induction is elevated by some of the procedures (markedly by adrenalin, slightly and temporarily by caval occlusion), and lowered by other procedures (intestinal exposure

and aortic occlusion). Therefore, increased filtration of blood from the splanchnic and portal areas, or sequestration of blood in these areas by mechanical distention of the veins and capillaries² through local constriction of the portal radicles^{7, 8} cannot be regarded as essential to the development of shock. It is, however, possible to bring on shock by mechanically interfering with the outflow of blood from the portal area. Thus shock develops after plugging the smaller radicles of the portal vein in the liver by injecting into the portal vein a suspension of lycopodium spores.⁹ But unless the obstruction so produced is much more complete than any that could possibly develop through any known physiological mechanism, the time required for the onset of shock greatly exceeds that elapsing during the induction of the types of shock that are seen in the laboratory.

D. The peripheral resistance, as followed by a modification of a method first used by Bartlett in this laboratory, also in a study of shock,⁹ does not behave similarly during the induction of shock by the different procedures. Thus, as a result of exposure of the intestines, the peripheral resistance in both the somatic and splanchnic areas at first usually is increased; later, and usually only after the arterial pressure has started downwards, dilatation occurs. During caval occlusion the peripheral resistance is first increased, but soon becomes subnormal. During aortic occlusion the resistance is decreased, but it increases after de-occlusion, and usually remains high practically until the animal dies. Finally, those doses of adrenalin that bring on shock produce, through local action, an extreme and long-lasting peripheral constriction.

These observations clearly indicate that the condition in which the vasomotor centre finds itself in fully developed shock, namely, whether hyperactive or hypoactive, depends very largely upon the procedure employed for the purpose of inducing shock. Neither reduced nor enhanced vasomotor activity is an essential condition of shock. But in any event, the center is apt to become hypoactive after the circulation has been deficient for some time.

Analysis of the data derived from this study of the circulation in shock, while indicating that the low arterial pressure in advanced shock may in part be due to some inefficiency of the heart, and sometimes, also, to some decrease in the activity of the vasomotor centre (though increased tone is more common), clearly demonstrates that these two deficiencies, even when present, are not in themselves sufficient to account for the failure of the circulation. If, then, the efficiency of the heart is but little reduced, and if increased vasomotor tone is the rule, there is left as the only other possible explanation of the low blood-pressure of shock an insufficient return of blood to the heart.

BLOOD-VOLUME.—In an effort to ascertain whether there is a deficient blood supply, a study was made of the blood-volume in animals in shock.¹⁰ For this purpose the method of Meek and Gasser¹¹ was employed. This method consists in allowing a known amount of gum acacia to circulate in the blood stream for a period of ten minutes and then in determining the per cent. of gum in the blood. The method, therefore, determines the amount

of blood participating in the circulation in the course of ten minutes. The blood-volume changes were followed also by counting the red corpuscles and by estimating the per cent. of hæmoglobin. The latter two methods have shown that depletion of the blood plasma occurs in all types of shock, indicating a reduction in blood-volume averaging 20.3 per cent. But the acacia method of determining the blood-volume brings out the fact that the loss in volume by this concentration of the blood (disappearance of plasma) in many instances does not account for the total reduction in blood-volume. The blood unaccounted for by concentration must therefore be out of circulation; it must be stagnant somewhere.

These results confirm the well-known fact¹² that but little blood can be obtained by bleeding an animal in shock. The following experience is cited by way of illustration of what is meant: An animal weighing 15 kilo was put into shock. At a time when it still had a fair arterial pressure, 70 mm. Hg, as much blood was drawn from the carotid artery as it was possible to obtain by the use of all of the devices for obtaining a maximum yield. Only 100 c.c., or one-twelfth of the estimated normal volume, were obtained, whereas at least three-fifths could easily have been obtained from a normal animal. It follows from such observations that the volume of blood that is in the body of a shocked animal and which is thoroughly mixed in the course of ten minutes is very much larger than the quantity that effectively participates in the circulation.

In this connection attention should be called to an observation indicating that the animal in shock attempts to combat the reduction in blood-volume by adding tissue fluids to the blood. Refractometer estimations have shown that even while plasma is disappearing from the blood stream, its protein content may be diminishing¹³; that is to say, the plasma is becoming more dilute. It would, therefore, seem that all parts of the vascular bed are not affected alike during the induction of shock; in some parts the normal reaction to decreased volume, namely, the passage of fluids from the tissues to the blood stream, is possible, whereas in other parts the alterations are such as to allow of outward transudation only. Our observations furnish some reasons for believing that the ability of the organism to thus make good the loss in blood plasma diminishes as shock deepens.

RESERVE ALKALINITY.—The reserve alkalinity, as indicated by the CO_2 in the plasma of arterial blood (Van Slyke method), is reduced in all types of shock; but in our experience the reduction is extremely variable.³ The volume per cent. of CO_2 may be below 20, that is, extremely low, or it may not be below a figure often obtained in estimations made before starting to induce shock. We have seen heavily morphinized animals with 20 volume per cent. of CO_2 and an arterial pressure of 103 mm. Hg., only 3 mm. below the initial arterial pressure. Therefore, acidosis, though probably always present to some degree, can scarcely be regarded as a cause of the low arterial pressure of shock, as some have believed¹⁴, or even as an essential feature of the shock complex.¹⁵

PATHOLOGY.—At autopsy, which in our hands, unfortunately, has never been as thorough as pathologists might desire, the organs of the animals dead of all of the types of shock we have studied, present a very similar picture.³ The intestines are apt to contain some bloody material; and the mucosa, especially of the upper end of the jejunum, usually is deeply injected and of a bluish-red color. The spleen may be uniformly or unevenly enlarged and may contain hemorrhages. The liver usually is not enlarged and may contain less than the normal quantity of blood. Rarely the gastric mucosa shows hemorrhagic areas. The most remarkable feature, though, is brought to light by microscopic examination of the intestines: *in all types of shock the capillaries and venules of the villi are tremendously distended by solid masses of red corpuscles.*

THEORETICAL.—If, now, we pause to consider the methods by which we have succeeded in producing shock, we are struck by the fact that at least three of the four, namely, caval occlusion, aortic occlusion, and massive doses of adrenalin, involve reducing for some time the rate of movement of the blood through a considerable portion of the body; and if we accept the prevailing view that the blood stream eventually is slowed in regions that are the seat of an inflammatory process, it is to be presumed that as a result of intestinal exposure also, the blood stream in the splanchnic area is slowed. Furthermore our experiments, showing that, as a rule, traumatizing the abdominal viscera results in a certain amount of general constriction, and Gesell's observation⁵ that the volume flow of blood through the salivary gland under similar circumstances is markedly reduced, indicate that during the development of this type of shock, also, the blood stream is slowed throughout the whole of the body.

Mall and Welch have followed under the microscope the changes in the flow of blood occurring in the smaller mesenteric vessels of the dog when the rate of blood-flow through them is slowed by partial obstruction of the mesenteric artery. In his classical article on Embolism and Thrombosis, Welch¹⁰ describes these changes about as follows: The smaller and then the larger (microscopic) veins become more and more distended with red corpuscles and all of the phenomena of an intense venous hyperæmia appear. The red corpuscles accumulate in clumps or in solid columns. *This change may become permanent, producing an evident obstacle to the forward movement of the blood.* The same phenomena of distention with red corpuscles, clumping, and stasis appear gradually in the capillaries. With this partial blocking of the veins and capillaries the corpuscles begin to pass through the wall of the vessels by diapedesis.

Although Mall and Welch seem inclined to attribute this clumping of corpuscles to the absence of pulsation, their evidence does not preclude mere slowing of the blood-stream as the cause of the phenomenon. Assuming that slowing is the cause, we have in the peripheral mechanism thus started by a slowing of the blood-stream a means of accounting for all of the characteris-

tic changes in the circulation that occur in experimental shock. The concentration of the blood and the reduction in blood-volume are explained by the transudation of plasma which must precede the diapedesis observable under the microscope. The failure to obtain by bleeding, as much blood as the blood-volume methods indicate is present in the body is accounted for by the dilatation and plugging of the capillaries and venules. Reduction in reserve alkali is known to accompany deficient oxygenation of the tissues. While the low blood-pressure, naturally, is to be referred to the reduction in effective blood-volume due in part to the actual reduction by transudation and in part to the stasis in the capillaries and venules.

II. REVIEW OF EXPERIMENTS ON TREATMENT

Preliminary Experiments.—While making estimations of the blood-volume in shock by the acacia method it was observed¹⁰ that the concentration of the blood that ordinarily occurs during the development of shock, did not occur, or, at least, was not nearly as marked as usual, in animals that had received a preliminary dose of 20 per cent. gum acacia. This observation forms the basis of our experiments on the treatment of shock. An investigation of this action of strong gum acacia led us¹³ to conclude that in all probability it is referable in part, at least, to the osmotic pressure it exerts, and possibly in part to other properties.

By following the changes in hæmoglobin content of the blood it was found that when 25 or 30 per cent. gum acacia is quickly injected into the circulation the blood dilutes slowly, the maximum dilution being attained in from 25–30 minutes, the subsequent return to the normal concentration requiring many hours. This reaction to the injection of a hypertonic solution of the colloid gum is very different from that given by the injection of hypertonic crystalloid solutions. Thus a hypertonic (18 per cent.) glucose solution injected into the same animal some days subsequently led to a similar dilution of the blood; but in this case the maximum dilution was attained practically instantaneously, and within five minutes practically all of the water that had been drawn into the circulation by the glucose, had again returned to the tissues. By first injecting a strong gum solution and following it immediately with the strong glucose solution we found it possible, both in normal and in shocked animals, to expand the blood-volume as rapidly as injected crystalloids (glucose) are known to attract water into the bloodstream, and to maintain that expansion as long as colloids (gum acacia) are known to maintain dilution of the blood.

A series of experiments on animals in shock was then performed in order to ascertain whether the course of shock could be influenced by the administration of gum alone or of gum in combination with crystalloids. It was found that such solutions as simple isotonic¹⁷ * (7 per cent.) gum acacia, 6 per cent. gum acacia in 2 per cent. NaHCO_3 , 25 per cent. (hypertonic) gum acacia (sodium salt) and 5 per cent. (hypertonic) NaHCO_3 given in succession, and 25 per cent. (hypertonic) gum acacia and 18 per cent. (hypertonic)

* Recent estimations indicate¹⁰ that 7 per cent. gum acacia is hypertonic.

GUM ACACIA AND GLUCOSE IN SHOCK

glucose, also given in succession, all restore and maintain with equal effectiveness the blood-volume and the blood-pressure, while the bicarbonate solutions (at least the stronger of the two) restore the alkali reserve also. The ultimate result, however, that is, whether or not the animal recovered from shock, did not seem to be influenced by thus successfully treating these symptoms of shock. It followed that the efficacy of any proposed treatment of shock cannot be judged, or at least not solely, by the effect it may have upon these manifestations of shock during the limited period of observation of an experiment as ordinarily performed. An empirical study of the ultimate effects of administering these and similar solutions to animals after standard traumatization seemed, therefore, to be the only way of obtaining the desired information.

Experiments on the Treatment of Standardized Traumatization.—The ideal test would have been to have inflicted that amount of damage from the effects of which animals could just not recover; that is to say, the minimal fatal dose of damage, and to have determined whether treatment of animals so prepared saved life. It was found, however, that when this amount of damage was done the animals invariably died, irrespective of the treatment administered. After many trials we³ adopted, as the standard damage, so clamping the inferior vena cava as to hold the arterial pressure at 40 mm. Hg for two and a quarter hours. It was found that if the arterial pressure did not fall within two hours after removing the clamp, animals so treated stood a 52 per cent. chance of recovering. It might be added that if the arterial pressure began to fall consistently before two hours had elapsed, again, no form of treatment whatever prevented a fatal issue. It is needless to state that aseptic precautions were carefully observed.

Large numbers of animals, after exposure to this measured traumatization, were treated with (a) 6 per cent. gum acacia in 2 per cent. NaHCO_3 , 12 c.c. per kilo of body weight; (b) 25 per cent. gum (sodium salt) followed by 5 per cent. NaHCO_3 , of each 5 c.c. per kilo; (c) 25 per cent. gum followed by 18 per cent. glucose, of each 5 c.c. per kilo, or (d) 25 per cent. gum in 18 per cent. glucose, 5 c.c. per kilo.

Our reasons for trying just these therapeutic measures were as follows:

Solution *a* we took as representative of a solution of gum and of a salt practically isotonic with the blood (though to be sure it was alkaline also). An additional reason for using it was that it was then the solution recommended by the English committee¹⁷ for the treatment of shock at the front. More recently the English committee have given their support to a solution consisting of 6 per cent. gum acacia in 0.9 per cent. NaCl .¹⁸ The efficacy of this solution we have not had the opportunity to test.

Treatment *b* was used mainly for the purpose of determining the effect of a hypertonic salt, which at the same time was strongly alkaline, in combination with hypertonic gum. It served to test not only the effect of restoring the blood-volume by osmotic action, but also the efficacy of alkalies, which were then being employed in the treatment of shock¹⁹ and which have from

time to time been advocated for that purpose on the basis of their effect upon the blood-pressure^{20, 21, 22, 23} and on the basis of theoretical considerations.⁵ In order to obtain the desired osmotic effect the bicarbonate, as used by us, was in slightly greater concentration than it was being employed in man; but the dose per unit of body weight was less and the rate of administration was slower. The fact that the alkali was used in combination with gum acacia complicates somewhat the inferences our results seem to justify, though gum acacia in other combinations has not proved harmful.

Treatment *c* involved the use of hypertonic glucose, which experiments with Woodyatt²⁴ had let us to believe acts beneficially in shock. It has been shown by Woodyatt and co-workers²⁵ and more recently by Litchfield²⁶ that man, even when desperately ill, is not injured, indeed is benefited, by extraordinarily large doses of hypertonic glucose solution given at a subtolerant rate. Furthermore, hypertonic solutions in general (urea, glucose, NaCl) increase the cardiac output and dilate the arterioles, apparently through some specific action.²⁷ These, and other responses to be referred to later, are exactly the ones best calculated to counteract the mechanism which we believe is at the basis of the vascular failure of shock.

Treatment *d* was used for the same reasons and also for the reason that by it the deleterious effects of the high viscosity of the strong gum solution, which are operative for a time during the injection of the gum in treatments *b* and *c*, are completely obviated by the immediate dilution of the gum by the water attracted from the tissues by the hypertonic glucose. Solution *d* was so given (5 c.c. per kilo an hour) that the glucose entered the circulation at a rate that is just subtolerant for the normal animal.²⁵

TABLE I
RESULTS OF TREATING MEASURED TRAUMA

Treatment	No. of animals	Deaths		
		Total, per cent.	After excl. abd. hem., per cent.	After excl. cardiac cases, per cent.
Controls.....	23	48	37	45
(a) 6 per cent. gum in 2 per cent. bicarbonate, 12 c.c. per K.....	20	45	35	42
(b) 25 per cent. gum and 5 per cent. bicarbonate, 5 c.c. of each per K.....	16	56	50	53
(c) 25 per cent. gum and 18 per cent. glucose; 5 c.c. of each per K.....	20	45	31-35	39
(d) 25 per cent. gum in 18 per cent. glucose; 5 c.c. per K. hr.....	21	24	6-11	20

The essential results that came of this study are collected in Table I. This table shows, 1, that treatment *b* unquestionably is harmful; 2, that treatment *d* unquestionably is beneficial; and 3, that while treatments *a* and *c* seem to accomplish some good, the variations from the results of the control series are so slight that they unquestionably fall within the limit of the experimental

error. It should be added that the harmful effects of treatment *b* were also clearly manifested by the shorter span of life of the fatal cases.

No ill effects of giving gum acacia have been seen except early in our work when the strong gum solution was run very rapidly into the vein of an animal almost moribund. In several instances of this kind the heart became irregular and stopped as though it had passed into fibrillation. Since then we have given the gum solution to at least 200 animals, including those collected in Table I, animals so seriously injured that their lives actually were in the balance, and not a single bad effect has been observed. If there is any one thing we are convinced of, it is that gum acacia when given slowly is entirely innocuous.

Hemorrhage Does Not Contra-indicate the Use of Hypertonic Solutions.—Shock in man often, in war surgery perhaps always, is complicated by hemorrhage. The use of the strong gum-glucose solution in the treatment of cases complicated by dangerous hemorrhage would therefore not be justifiable unless it could first be shown in animals that such a hemorrhage is not a contra-indication to its administration. The results of a series of experiments planned for the purpose of testing this matter have been to show³ that even when the corpuscles are reduced to an extremely low level by a hemorrhage that ordinarily proves fatal, the gum-glucose solution accomplishes a certain amount of good; deleterious effects were never observed.

III. OBSERVATIONS ON THE USE OF THE HYPERTONIC GUM-GLUCOSE SOLUTION IN MAN

Methods.—Preparation of the Solution.—The gum-glucose solution that was employed in most of the animal experiments described above and in the treatment of the cases of shock and allied states, to be described below, was made up as follows:

Two hundred and fifty grams gum acacia, "extra select," in pearl form (gum arabic, U.S.P.) are ground up and dissolved in 720 c.c. hot water, freshly distilled from glass. Constant stirring is necessary to prevent gumming of the acacia into a very slowly dissolving mass. To this solution 180 gm. pure glucose are added. The whole will amount to about 1000 c.c. The solution is filtered under pressure through a thick pad of glass wool, heated in an autoclave to a temperature of 120° C. for a few minutes, preferably in a sealed, high pressure, flask and then filtered under pressure through an alundum filter dish of a porosity of R. A. 98.

The filtered solution is then filled into tubes of the shape shown in Fig. 1, made to fit the cup of our largest (100 c.c.) centrifuge. Larger tubes, holding about 350 c.c. would be preferable, for then the maximum dose for man would be in one container; but we have been unable to obtain the use of a centrifuge of sufficient capacity to take larger tubes. In order to avoid the formation of bubbles, which, in such a viscid solution, are apt to persist for some time, the solution should be made to run down the side of the tube.

The tube, when filled, is sealed hermetically at *A*, and sterilized by heating to 120° C. in an autoclave for fifteen minutes (no longer).* A slight flocculent precipitate is apt to form during sterilization. This is thrown down firmly against the bottom of the tube by centrifuging the material for about an hour.

Administration.—The ampoule is opened by filing a scratch and breaking

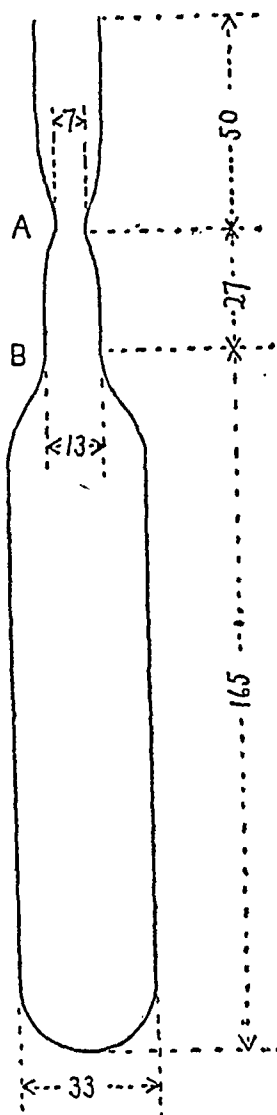


FIG. 1.—Ampoule. Reduced to $\frac{1}{8}$ natural size. The dimensions are given in mm.

at *B* (Fig. 1). The opening thus made is flamed and the contents of the tube are so decanted as not to stir up the sediment. The sediment is usually firmly fixed to the bottom of the tube, but in order to avoid the danger of pouring it off, the last few cubic centimetres should not be decanted.

* In order to avoid the change that occurs in both glucose and gum acacia solutions as indicated by a slight deepening of color when they are sterilized under pressure, we at first sterilized them by pasteurization. Our experiments have shown, however, that the solution, even after several heatings to 120° C., is quite as efficacious and quite as innocuous as the pasteurized material. We, therefore, have come to employ the autoclaved solution only.

GUM ACACIA AND GLUCOSE IN SHOCK

For the slow and steady intravenous administration of such a viscid solution special apparatus is needed. The apparatus devised by Woodyatt²⁵ probably would answer every requirement, but it is expensive and can be used only where electricity is available. We have designed for the purpose a burette with a capacity of 350 c.c. and a bore of 35 mm., calibrated upwards from the stem in small divisions (5 c.c.). Owing to the high viscosity of the fluid, its rate of inflow can be nicely controlled simply by varying the elevation of the burette; while the calibration of the burette from the stem upwards, makes it possible to utilize the last drop of the material. In order to avoid trapping air bubbles in the solution during the transfer, it should be made to run down the side of the burette.

Again owing to the high viscosity of the gum-glucose mixture, the injection needle must have an unusually large bore. It need not, though, be quite as large as the needles that have been recommended for use in the transfusion of blood.²⁸ The needle we have used (Fig. 2) is of silver, with inside and outside diameters at least at the point of 1.5 and 1.8 mm. respectively. Ordinarily it is not at all difficult, if it is properly pointed and sharpened, to insert a needle of this size into the vein through the skin. The author has convinced himself of this through use of the needle in a large series of cases



FIG. 2.—Injection needle. Natural size.

for the purpose of drawing blood samples for the Wassermann test. If, in any case, difficulty is anticipated on account of the smallness of the veins, the vein should first be exposed. After the burette and tube have been filled with the solution to the total exclusion of air, the needle is inserted into the vein, allowed to fill with blood without permitting of any loss, when the tube is rapidly slipped over the end of the needle which is so shaped as to facilitate this step. It is needless to add that all of the apparatus must be carefully sterilized and that the usual aseptic precautions must be observed.

The dose we used in the animal experiments was 5 c.c. of the solution for each kilo of body weight, and in order not to exceed the tolerant rate of glucose administration (0.8–0.9 gm. per kilo and hour), this dose was given in one hour. This particular dose was selected because it was found by experiment to be about the amount necessary to restore to normal the blood-volume of shocked animals. As no ill effects were produced by twice this dose administered at twice this rate, it may be regarded as a perfectly safe one for man. Experience has confirmed this conclusion. We have never repeated the dose, mainly, as will be seen, because we have not had the opportunity in instances in which a second dose was indicated. We feel convinced, though, that it would be perfectly safe to give, say, one-half the maximum dose some 8 to 10 hours after a maximum dose has been given.

Criteria of Effects.—The animal experiments made it clear that the immediate effect upon certain of the manifestations of shock, namely; the blood-

pressure, the blood-volume, and the reserve alkalinity, is of no value as an index to the ultimate efficacy of any treatment of shock. It was on this account that our conclusions were based solely upon the number of animals surviving a measured amount of damage. Complete recovery from the state of shock must be and is our final criterion of the efficacy of treatment of shock in man also. But while it is true that the state of these signs at any given moment is no sure index to the ultimate outcome, nevertheless, it is obvious that continuous changes in them must be indicative of a corresponding change in the condition of the patient. The arterial pressure is employed almost universally as a measure of the grade of shock. Furthermore, of the recognizable signs of shock, the arterial pressure is the easiest to gauge and to follow in man. For these reasons, and though we agree with Gesell⁵ in believing that the circulation may be very seriously disturbed at a time when, through compensatory processes, the arterial pressure is still normal, the arterial pressure has been carefully followed in all of our cases.

For the purpose of following *the arterial pressure* the sphygmomanometer of the author²⁰ has been employed. The arm band is adjusted to the arm, and, unless it is stated to the contrary, its position is not changed, nor is it tightened or loosened during the entire series of readings. Likewise all of the other conditions affecting the registration of the pressures are kept constant throughout the observations in any given case. The variation in the amplitude of the oscillations, graphically recorded by the instrument in the successive readings, therefore, is an *absolutely objective index* to variations in the condition of the circulation. And, as the amplitude of the maximum oscillation as recorded by the sphygmomanometer under any fixed set of conditions is affected by the pulse-pressure alone, we have in the records as they stand an indication of the condition of the patient's circulation that is quite as significant as the blood-pressure itself.³⁰ In this respect we are in full accord with Maury and Soulé.³¹ While obtaining each record the effort, of course, was made to read the systolic and the diastolic pressures, employing as the criterion of the former the change in the form of the wave³² and of the latter the first abrupt and consistent diminution in amplitude. It not infrequently happened, however, when the circulation was poor and the recorded pulse amplitude, consequently, was very low, that the diastolic pressure alone could be read. It may be of interest to add that in such instances the pulse either could not be felt at all, or was scarcely palpable, and that attempts to read the pressure by the auscultatory method also failed, and not alone in the case of the systolic pressure but of the diastolic pressure as well.

Blood-pressure readings are subject to a rather large experimental error, especially when the pulse amplitude is small. We therefore desire to emphasize the data that are furnished directly by the pulse amplitude as recorded graphically, rather than those derived indirectly by the readings of manometer. The former, to repeat, are subject to no experimental error and can be interpreted from reproductions of the originals; whereas, the latter

depend upon a judgment made by the observer, which cannot be evaluated by the reader. All of our records, therefore, are published herewith.*

CLINICAL CASES.—Despite the fact that the clinical material of four large St. Louis hospitals has been at our disposal, we have had, since August, 1918, only ten opportunities to administer the gum-glucose solution. As will be seen, many of the cases were really not suited to the purposes of this study. Some of them, without doubt, were not cases of traumatic shock properly so called; pure hemorrhage, fat embolism, toxæmia, and general infection, probably, are amongst the etiological factors. But the cases have not been selected. At first (Cases II–VIII) the gum-glucose solution was given when the surgeon, through whose kindness I was called to see the case, regarded the condition of the patient as desperate, and provided consecutive blood-pressure readings made by myself bore out this opinion by indicating a continuing impairment of the circulation from which spontaneous improvement seemed unlikely to occur. More recently (Cases XI and XII), after experience had given us confidence, the solution has been given when the circulation was seriously impaired, without waiting to see whether the condition was going to be able to take care of itself. Many of the cases I was called to see were not treated because the condition of the patient, as indicated by the arterial pressure, did not seem to be sufficiently aggravated. In every instance, excepting one very flagrant one, cited below, the decision not to proceed with treatment has been justified by the subsequent course of the case. In one instance, in which the patient definitely was in shock, treatment was not given because of internal bleeding. Preparations in this instance were made to start the injection just as soon as the bleeding should be controlled, but the patient died during the operation.

CASE I.—*Crushed foot; shock; not treated.* The first case we were called to see we were unable to treat on account of an accident to the solution on the way to the hospital.† The patient was a colored boy whose foot had been crushed. Apparently there had been relatively little hemorrhage, yet the shock was extreme. The diastolic pressure was about 40 mm. Hg, the systolic pressure could not be determined. The pulse amplitude (Fig. 3, records A, B, C) of 1.3 mm. was quite as high as, indeed considerably higher than, in many of our other cases of shock. The patient died about four hours after I had been called to see him.

* The conditions obtaining at the bedside, especially when the patient is desperately ill, are not conducive to the obtaining of unblemished records on smoked paper. The nurse's apron strings, the hand of the restless patient, etc., etc., seem to seek contact with the smoked paper; and the muscular contractions of the patient often cause the recording lever to sweep over the recording surface. The present experiences have led the author to add to the sphygmomanometer certain simple devices which should have the effect of minimizing difficulties of this character. The records reproduced as figure 9 *et seq.* had the advantage of these devices. We ask the indulgence of the reader in respect to the smirches upon the records published herewith.

† This happened before the solution was put up in hermetically sealed containers.

CASE II.—*Gunshot wounds of thigh and buttocks; typical shock.* The patient, a colored male, had suffered considerable loss of blood, though the hemorrhage was not regarded as dangerous. The temperature on admission was 96.8° , but rose to 100.6° just before treatment. The patient was cold, but perspiring freely; his pulse very small, 120 to the minute; the arterial pressures, systolic, 80, diastolic, 70 (records 1, 2, 3, Fig. 3). The diastolic pressure, therefore, was not very low but the pulse pressure was dangerously small. As the patient had been in this condition for some hours without showing any improvement it was decided that something should be done.

It was estimated that the patient weighed 70 kilo. The dose of gum-glucose solution, on the basis of our animal experiments, might therefore have been as large as 350 c.c. given in one hour. As a matter of fact the dose given was 270 c.c. in the course of one hour forty-five minutes. During the administration of the solution the recorded amplitude increased from 1.5 mm. (record 4) to 5.5 mm. (record 35), the pressures, especially the systolic, rising constantly and finally reaching, systolic, 120, diastolic, 85. The pulse-rate, as may be seen by the spacing of the pulses in the successive records, decreased steadily, reaching 77 at 4.20. Three hours later, and the next morning, the pressures were 120, 80–85, the pulse amplitude (new adjustment of arm band), 6.5 mm. All of the shock symptoms disappeared during the injection, the patient falling asleep before its conclusion. There was no temperature reaction to the injection. Recovery was uninterrupted.

CASE III.—*Panhysterectomy; hemorrhage; shock (?) ; infection (?)*. White, female. The patient was seen a few hours after panhysterectomy during which there had been considerable and extensive soiling of the peritoneum. Her skin was of a dusky hue, the extremities cold and clammy, the pulse, when palpable at all, thready and uncountable. The diastolic pressure was 50 when the patient was first seen (Fig. 4, records 1–4), falling to 40 later (record 7), and to 30 mm. Hg (record 8) when the needle was inserted into the vein. The systolic pressure was undeterminable. The respirations were rapid, alae nasi dilating, the temperature 105.6° .

The patient's weight was estimated at about 50 kilo. She was given 200 c.c. of the gum-glucose solution in the course of 1 hour 15 minutes. The recorded pulse amplitude increased from less than 1 mm. (record 8) to over 2 mm. (record 18); and the diastolic pressure rose to 50 mm. Hg, the systolic pressure at the same time becoming legible at 80 mm. Hg. There was possibly a slight improvement in the patient's general condition. The improvement in circulation was not sufficient, however, to hold out much hope for recovery, and it was not maintained. An hour and a half later (record 21) the pressures were 75–45, the amplitude irregular, the temperature 106° . The general condition of the patient was now getting worse again and she died four and a half hours after terminating the injection. There was no autopsy.

CASE IV.—*Primary carcinoma of the liver; splenectomy; shock (?) ; primary and secondary hemorrhage.* White, male. On October 13 splenectomy was done for what seemed to be Banti's disease. The



FIG. 4.—Blood-pressure records of Case III. Reduced $\frac{1}{2}$, approximately. Read from left to right and from below upwards. Description in text.



FIG. 5.—Blood-pressure records of Case IV. Reduced $\frac{1}{2}$. Read from left to right and from below upwards. Description in text.

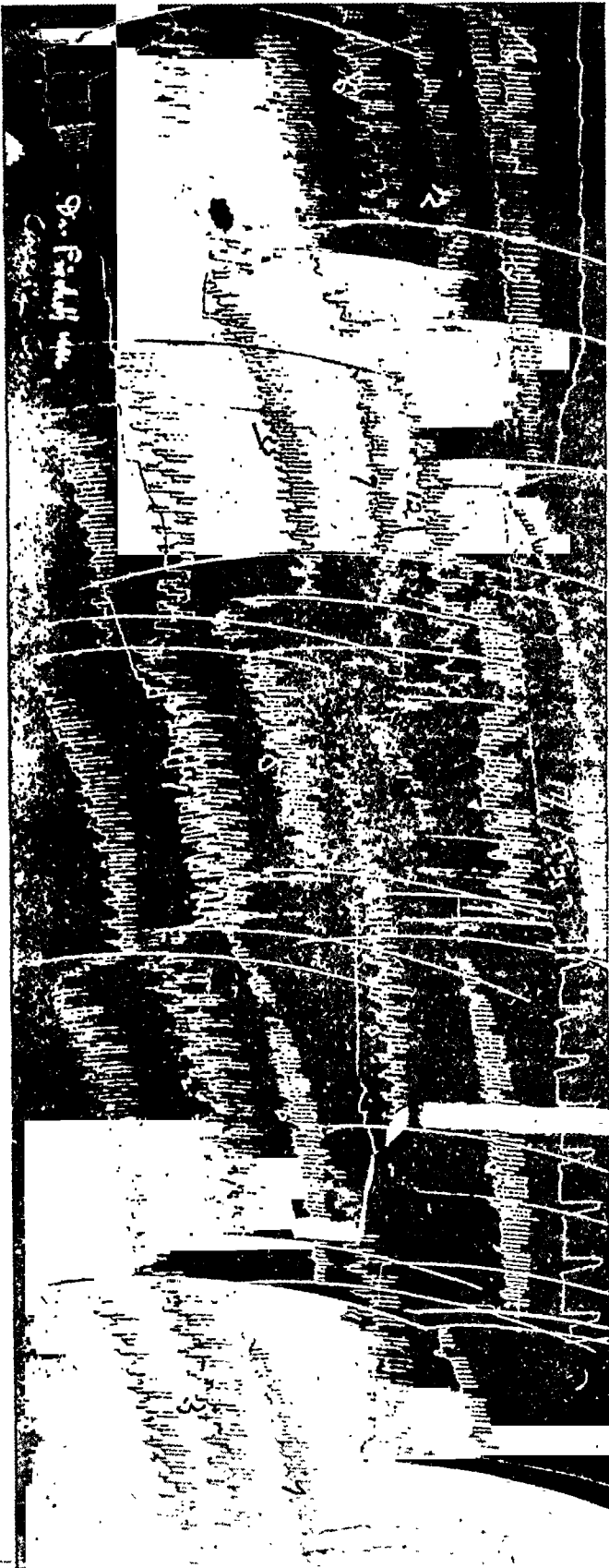


FIG. 6.—Blood-pressure records of Case V. Reduced $\frac{1}{2}$, approximately. Read from left to right and from below upwards. Description in text.



FIG. 7.—Blood-pressure records of Case VI. Reduced $\frac{1}{10}$. Read from left to right and from below upwards. Description in text.

GUM ACACIA AND GLUCOSE IN SHOCK

spleen was everywhere firmly adherent; the operation, consequently, was difficult, and the patient lost a great deal of blood. He did fairly well on the first day. On the second day, the note was made—"At 9 A.M. to-day the patient was *in extremis*. His pulse was thready and almost imperceptible; he looked pale and cold. This condition developed about 2 A.M. Though the patient was a little better at 1.15 P.M., it seems wise to try Doctor Erlanger's treatment."

When the patient was first seen by the author his condition seemed serious. His pulse was weak—120 per minute—he was cold, and he felt that he was going to die. He was vomiting some bloody material. His pressures were 100-80. The amplitude of oscillation (Fig. 5, up to record 4) varied somewhat from record to record; it was not as small, however, as in some of our other cases. If the patient was not in shock, he was in what was regarded as a condition closely approaching it. It was, therefore, decided to administer the gum-glucose treatment.

The patient received 200 c.c. in the course of one hour ten minutes. More might have been given, but it was not regarded as necessary. Hypodermoclysis also was started while the solution was being administered. The pulse amplitude increased steadily during the injection, growing from 2.0-3.0 mm. (record 4) at the start to 5.0-5.5 at the finish (records 25, 26). The pressure readings at this time were 110, 80-85. The pulse-rate also diminished somewhat, from 120 to 105. The patient fell asleep toward the end of the period. Some three hours later (record 28) the pulse amplitude and the blood-pressures had receded somewhat; they were 4.0-4.5 mm. and 100, 80. The clinical note on the patient's condition reads: "Doctor Erlanger called to see the patient, advised gum-glucose treatment, treatment given, patient rallied."

The next morning (October 16) the patient's circulation was much improved, the pulse amplitude (new adjustment of arm band, see record 29) was 8.5 to 9.0 mm., the pressures 120-80; the pulse-rate, though, was still quite rapid, 120 per minute. The patient did fairly well during the 17th, though some blood continued to appear in the vomitus. On the morning of the 18th, he vomited 300 c.c. bright red blood; on the 19th he became irrational and violent, and as a result his wound broke open, and he died that day. There was no temperature reaction to the injection, the temperature remaining normal for twenty-four hours, rising to 101°, 100°, 100°, respectively, on the three following days.

TABLE II

ESTIMATIONS OF THE RED CORPUSCLES, HÆMOGLOBIN AND CLOTTING TIME, CASE IV

Date	R. B. C. per mm. ³	Hb., per cent.	Clotting time
October 14.....	5,340,000	85	..
October 15.....	4,032,000	65	..
October 15 (2.00 P. M.).....	4,608,000	75	5'
October 15 (9.15 P. M.).....	4,056,000	75-80	7'
October 16.....	3,860,000	70-75	4'-20"
October 17.....	2,720,000	65-70	..
October 18.....	2,816,000	70	..
October 19.....	1,912,000	40-50	..

Estimations of the red corpuscles, hæmoglobin and clotting time are shown in Table II. It is seen, if allowance be made for experimental error, that the patient steadily lost blood, and that the clotting time was not affected by the injection.

At autopsy there was found primary carcinoma of the liver with metastases to the diaphragm and lung; cirrhosis of the liver; ruptured œsophageal varices; hemorrhage into the stomach and at the site of the splenectomy; general arteriosclerosis; and chronic interstitial nephritis.

To summarize, during the injection of somewhat less than 3 c.c. per kilo of body weight, 200 c.c. in all, of the solution, the circulation was decidedly improved though part of the improvement was lost subsequently. Some twelve hours later the pulse amplitude and the blood-pressure were found to be normal, though the pulse-rate remained high. These changes occurred despite evidence of continuous secondary hemorrhage which had begun before treatment and which apparently was not aggravated by the treatment. It is obvious that the whole of the recovery of the circulation was not attributable to the gum-glucose; it is quite possible, though, that by the treatment the patient was tided over the critical stage of the post-operative period. Death was due to secondary hemorrhage from ruptured vessels.

CASE V.—*Compound comminuted fractures; shock or fat embolism.* White, male. At midnight I was called to see a "case in shock with low pressures." The patient was a man who had been struck by an automobile and had sustained compound comminuted fractures of the left thigh and of the right leg. I saw him at about 1 A.M. He was then under ether and the operation was well advanced. The pulse was good, the arterial pressures 140, 90, the recorded amplitude 6.0 mm. (Fig. 6, record 1). I decided that the patient was not in shock despite the insistence of the surgeon to the contrary, who now based his opinion upon the observation that the skin incisions did not bleed. Table III and the records (Fig. 6) show that for a time the circulatory conditions remained constant. Later (record 4 *et seq.*), the pressures and the recorded amplitude started downwards. At 2.35 (record 12) the pressures were 90 (palpatory), 65, the amplitude 3.8 mm. The patient now began to struggle, so that pressure estimations could not be made until he was quieted, one hour twenty minutes later, by repeated doses of morphine. In the interval, judging by the pulse, the patient's condition grew steadily worse and preparations were made to inject the gum-glucose solution. The records, therefore, do not show the patient's circulation at its worst. At 3 A.M., when injection of the mixture was started, the patient was blue, pulseless, and gasping. By 3.42, 90 c.c. had been given, and the pulse was better and constantly improving. By 3.56 the patient had quieted down and we succeeded in obtaining record 13. The diastolic pressure alone was legible; it was 60 mm. Hg the amplitude 6.0 mm. Record 14 was obtained at 4.12, the pressures being 95 (palpatory), 60, the amplitude 6.0 mm.; record 15 at 4.23, the pressures being 90 (palpatory), 65, the amplitude 5.2 mm. At this time the injection was ended, the patient having received 265 c.c. The pulse was now fair, but did not feel normal and it was still quite

GUM ACACIA AND GLUCOSE IN SHOCK

rapid. Neither were the pressures normal; the respiration, though, was much improved. It was decided not to give more of the solution, however, but to wait and see how the patient reacted. The pressures, though, started to fall again immediately after terminating the treatment, the diastolic pressure being 60 and the amplitude 4.5 at 4.42 (record 16); and 55 and 4.0 at 5.35 A.M. The interne was instructed to follow the pressure and to inform me if it fell any further. This was not done, despite the note in the history made at 7.15 A.M.—“pulse very weak, 136, respiration somewhat labored.” It was not until 12 M. that I was called to the hospital. It was 1 P.M. when I reached the

TABLE III
DATA OF CASE V

Record No.	Time A. M.	Pressures		Ampl. mm.	Remarks
		Syst. mm. Hg	Diast. mm. Hg		
1	1.08	140	90	6.0(?)	
2	1.09	140	95	8.0	
3	1.15	140	95	7.5	
4	1.30	135	90	5.5	
5	1.31	135	90+	6.0	Arm band tightened here.
6	1.45	120(?)	80	5.0	Anæsthetic off. Applying plaster casts.
7	1.50	115(?)	80	5.3	
8	2.00	110(?)	80+	5.0	
9	2.10	?	70(?)	4.0	
10	2.20	?	60-70	5.0	
11	2.30	?	70	4.5	
12	2.31	90 palp.	70	4.0	
12'	2.35	90 palp.	65	3.8	No more records until 3.56 on account of struggling of patient. Pulse steadily becoming worse.
	3.00				Patient pulseless and gasping. Starting gum-glucose.
	3.42				Pulse better. 90 c.c. in.
13	3.56	?	60	6.0	
14	4.16	95 palp.	60	6.0	Patient quieter, has had gr. $\frac{1}{2}$ morphine. 215 c.c. solution in.
15	4.23	90 palp.	65	5.2	265 c.c. in. Injection ended. Carotids throbbing, pulse still rapid. Started giving 21 oz. saline hypo.
16	4.42	?	60	4.5	
17	5.35	?	55	4.3	In bed. Has had 1 gr. morphine

ward and the patient then was dying. It was too late to start a second injection. There was no autopsy. This note occurs in the history: “The patient passed into a state of shock and was treated for the same while in the emergency room, and later was sent to the ward in fairly good condition, but became progressively worse and died at 1.25 P.M.”

The cause of the collapse in this case is not entirely clear; it may have been shock, properly so called, or it may have been fat embolism.³³ But whatever the cause, it is clear that, though the gum-glucose solution undoubtedly improved the circulation, the gain was not as complete as might have been desired, nor was it maintained. There was no temperature reaction to the injection.

CASE VI.—*Intestinal obstruction; shock (?)*. White, female. This was a case of intestinal obstruction of over five days' duration. There had been fecal vomiting. The temperature was 97° . I was asked to be present at the operation because the surgeon anticipated trouble. The operation, consisting of a lateral anastomosis of the small intestine, was performed under morphine-scopolamine anaesthesia. The upper part of the bowel was greatly distended; no attempt was made to draw off its contents. The patient was quite restless, and it therefore was difficult to obtain good blood-pressure records, especially toward the close of the operation.

In Table IV are given the blood-pressure readings and the maximum amplitude of the records shown in Fig. 7. It is seen that at first the readings were well within the normal range. At about the time the operation began the pressures and the oscillation amplitudes (record 5) started to fall, and it was not long before the pulse could not be felt and before the systolic readings became very difficult. The diastolic pressure, though, could be read with a fair degree of accuracy at all times; it fell from 100 to somewhere between 70–80 mm. Hg, where it remained, possibly rising a bit toward the end of the injection. With the diastolic pressure as a basis, the variations in the systolic pressure can be inferred from the variations in oscillation amplitude. It thus can be seen that the systolic pressure, and consequently the pulse pressure, were lowest at about the time (record 13) the administration of the gum-glucose mixture was begun. They then increased more or less constantly during the injection which terminated with record 23. It is obvious, therefore, that the injection caused a decided improvement in the circulation, though it did not bring it back to normal. At 10 A.M., that is, seven and a half hours after terminating the treatment, the report was received that the patient was doing well. But the notes in the history show that, whereas at 4 A.M., and again at 5.30, the pulse was of "fairly good volume, 140," at 8 A.M. it was "very weak and irregular." The temperature now, about five and a half hours after terminating the injection, was 99.4° . At 12 M. "the skin was cold and clammy, pulse almost imperceptible, the respiration slightly labored." At 1 P.M., almost eleven hours after treatment, the rectal temperature was 105.8° , and at 2.15 P.M. the patient died.

The rise in temperature requires a word by way of comment. There are a number of reasons for not regarding it as a reaction to the injection. The most important of these are: (a) The phases of an anaphylactic reaction are very much shorter than in this case; (b) the temperature reaction to bacteria-containing salt solutions is not so severe.³⁴ As there was no autopsy it is impossible to reach a definite conclusion with regard to this question.

CASE VII.—*Cerebral exploration; hemorrhage; shock (?)*. White, female. At 9.30 A.M. an extensive, rather bloody brain operation had been performed. Immediately after the completion of the operation, at about 12 M., the patient's pulse was weak and I was called to see her. The records marked "12.30" (Fig. 8) were then obtained. The pressure readings corresponding with them were 105, 80 and 100, 75.

GUM ACACIA AND GLUCOSE IN SHOCK

TABLE IV
DATA OF CASE VI

Record No.	Time P. M.	Pressures		Ampl. mm.	Remarks
		Syst. mm. Hg	Diast. mm. Hg		
2	11.38	130	100	8.0	Before operation, patient on table under morphine-scopolamine
3	11.40	130	100	8.0	Operation started
4	11.45	125	100	8.0	
5	11.47	125	100	7.0	
5'	11.49	125	100	7.0	
6	11.52	120	100	5.5	
	A. M.				
7	12.07	...	90	2.5	Pulse 140
8	12.39	110	90	4.5	Pulse 150
9	12.53	?	80	2.5	
10	1.02	90 palp.	80	3.0	After this tightened arm band.
11	1.20	...	80	1.5	
12	1.22	...	80	2.0—	Starting gum-glucose
	1.30	...	...	...
13	1.31	...	80	1.3	100 c.c. in.
14	1.40	?	?	1.0	
15	1.48	...	70	2.5	
16	1.50	...	80	2.5	
17	1.55	...	80?	2.5	
18	2.03	...	80	3.0	
19	2.04	100	80	3.0—	
20	2.15	...	70	3.5	
21	2.16	...	70	4.0	
22	2.17	85	70	3.0	
23	2.24	90	75	3.5	200 c.c. in. Injection ended
	2.29	...	...	...
24	2.30	...	75	4.0	Pulse 150
25	2.31	...	80	4.0	Record not satisfactory
26	2.35	...	80	3.5	

As the patient presented none of the symptoms of shock, and as the circulatory conditions did not seem to be especially threatening, it was decided to do nothing except administer fluids in the usual way. At 6 P.M. the patient's pulse was found to be "imperceptible" and I was asked to see her again. The records marked 6.20 were now obtained. The systolic pressure could not be determined accurately but it is obvious from the record, both on account of the low amplitude and of the shortened phase of oscillations, that it was very close to the diastolic pressure which was 75. Her pulse pressure obviously was dangerously small.

Preparations were immediately made to administer the treatment. Owing to the inconspicuousness of the veins it was necessary to cut through the skin in order to insert the needle. At 6.30 the injection was started. The records (numbers 3-6) made during the first ten minutes showed such great variability that instability of the pressures, such as cerebral cases commonly exhibit, was suspected. Record 7, made with a constant, optimum (diastolic) pressure upon the arm, confirmed this suspicion. The patient received 250 c.c. of the solution

in the course of one hour twenty minutes. This was close to the maximum dose, for the patient probably did not weigh more than 45 kilo. Fig. 8 shows the continuous improvement in the circulation during the injection, which terminated with record 24. The readings made with this record were 100, 78. Records 25-27, made two hours later, showed further improvement in the circulation, the pressures with these being 110, 75. The next morning record 28 was obtained; as this was made after a readjustment of the arm band the amplitude of oscillation is not entirely comparable with that of the previous records. It is obvious, however, that in this respect the circulation was quite normal. The corresponding pressures were 105, 78. There was no temperature reaction to the injection, the temperature before being 99.6°, and after, 99.2°. During the same night and the succeeding night the temperature rose to 100.8°. On the day following the treatment the note was made—"patient in good condition." The patient recovered completely from the effects of the operation, and was discharged from the hospital.

CASE VIII.—*Carcinoma of the rectum; hemorrhage; shock.* White, female. At 12.05 P.M., January 20, a Kraske operation was performed involving resection of the coccyx, a piece of the sacrum, about a foot of the rectum, and the posterior vaginal wall. It was necessary to enter the peritoneum. There was considerable loss of blood and "the patient was considerably shocked." I was called to see her at 3.30 P.M. and made the records labelled A (Fig. 9). The pressure readings were 80, 65. Her condition evidently was serious but it was decided to observe the trend of things before interfering. At 4.20 P.M. her pulse was 170, her "respiration jerky and shallow;" it was scarcely possible to get a pulse with the sphygmomanometer (see record 1). The diastolic pressure, roughly, was 5 mm. Hg, the systolic pressure could not be estimated. At 4.35 the administration of the gum-glucose solution was begun and in the course of two hours twelve minutes 220 c.c. were given. Owing to mechanical difficulties the rate of injection was much slower than was necessary. It was estimated that the patient received somewhat less than 5 c.c. of the solution per kilo of body weight. The injection terminated at 6.47 (record 28), when the blood-pressures were 100, 78, the pulse amplitude 3.0-4.0. The steady improvement during the treatment is clearly indicated by the figure. Records 29-33, made three hours later, with readings of 95, 70, and 3.0 mm., show that little, if any, of the improvement had been lost in the interval. Records 34-37 were made the next morning while the patient was nauseated. The systolic pressure ranged in the different estimations between 95 and 100 mm. Hg, the diastolic, between 75 and 80; the amplitude was 3.0 mm. In the evening the pressures were 110, 80. There was no temperature reaction to the injection. The clinical note made at 11 P.M. on the night of the operation reads, "Patient improved, condition now fair, pulse of fair quality—130-140." It should be added that the patient received 1000 c.c. salt solution subcutaneously while the gum-glucose solution was being given. A similar dose of salt solution was again given at 11 P.M.



FIG. 8.—Blood-pressure records of Case VII. Reduced $\frac{1}{2}$. Read from left to right and from below upwards. Description in text.



FIG. 9.—Blood-pressure records of Case VIII. Reduced $\frac{1}{2}$, approximately. Read from left to right and from below upwards. Description in text.

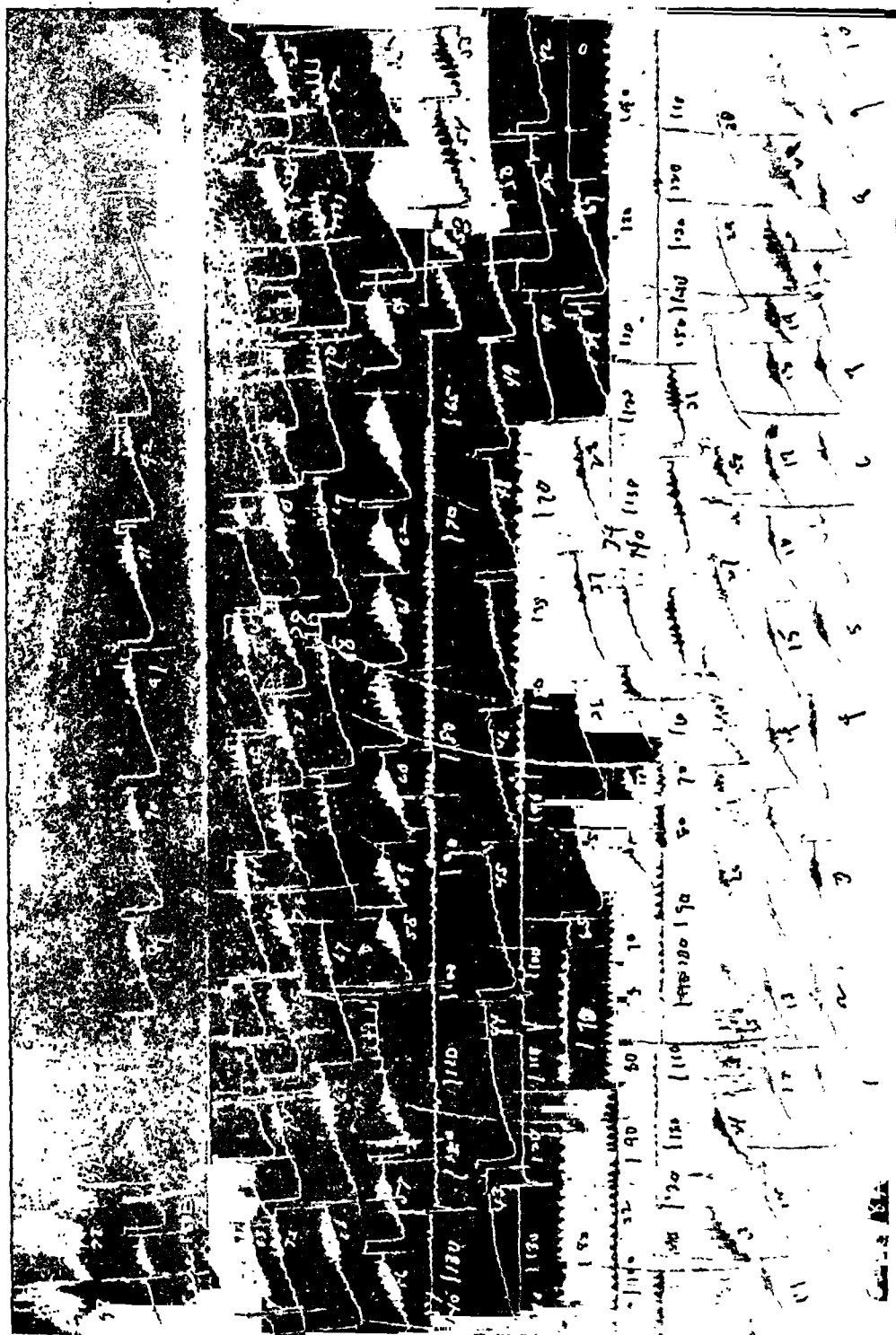


FIG. 10.—Blood-pressure records of Case X. Reduced $\frac{1}{4}$, approximately. Read from left to right and from below upwards. Description in text.

GUM ACACIA AND GLUCOSE IN SHOCK

The patient did well for four days, when symptoms of peritonitis developed. She gradually lost ground and died two weeks after the operation. Blood cultures made on the fifth day were negative.

CASE IX.—*Vaginal resection of cervical stump for carcinoma; hemorrhage; not treated.* White, female. The operation consisted of a very difficult vaginal resection of the cervical stump for recurrent carcinoma. There had been considerable hemorrhage during the operation, and an apparently profuse secondary hemorrhage from the vagina, subsequently. I saw the patient at 2.15 P.M. The pulse could scarcely be felt at the wrist and the sphygmomanometer recorded only the faintest flutter of a pulse. The arterial pressure could not be determined by any method whatever. The patient was conscious and somewhat restless. The skin did not feel cold. It was obvious that she was suffering from an extreme, acute hemorrhage, and transfusion of blood was advised. I was told that the preparations would require about a half hour. As I felt the patient could wait that long the gum-glucose solution was not given. But there was one unavoidable delay after another, and after each it seemed as though the transfusion would be started without further delay. But the result was that the transfusion was not started until 4.58 and the patient then was dying.

This unfortunate experience teaches the lesson that even when, in any given case, transfusion of blood is clearly the preferred treatment, the thing to do, pending preparations for blood transfusion, is to at once transfuse a blood substitute, such as simple saline, or better, isotonic gum-saline or hypertonic gum-glucose solution (cf. Case X). This case, in a way, may be regarded as another control (see Case I) to our series of treated cases. It will be noted that death occurred about three hours after I had been called to see the patient. It was the earliest death of the whole series.

CASE X.—*Excision of osteoma of cranium; extreme hemorrhage; shock (?)*. White, female, age sixty-one years. On March 3 an attempt to excise a bony tumor overlying the superior longitudinal sinus had to be interrupted on account of hemorrhage. I was called to see the patient immediately after this operation and after she had been transfused with blood. But her pressures were systolic 140–130, diastolic 100–90; and she presented none of the symptoms of shock. On March 6, the operation was completed. The hemorrhage again was extreme. Although the patient had already received 250 c.c. of blood, the pressures at 11 A.M. were about 85 (systolic) and 70 (diastolic), and the recorded amplitude (records 1–11, Figs. 10 and 11) was only 2 mm. Compared with those obtained three days earlier, these values were extremely low.

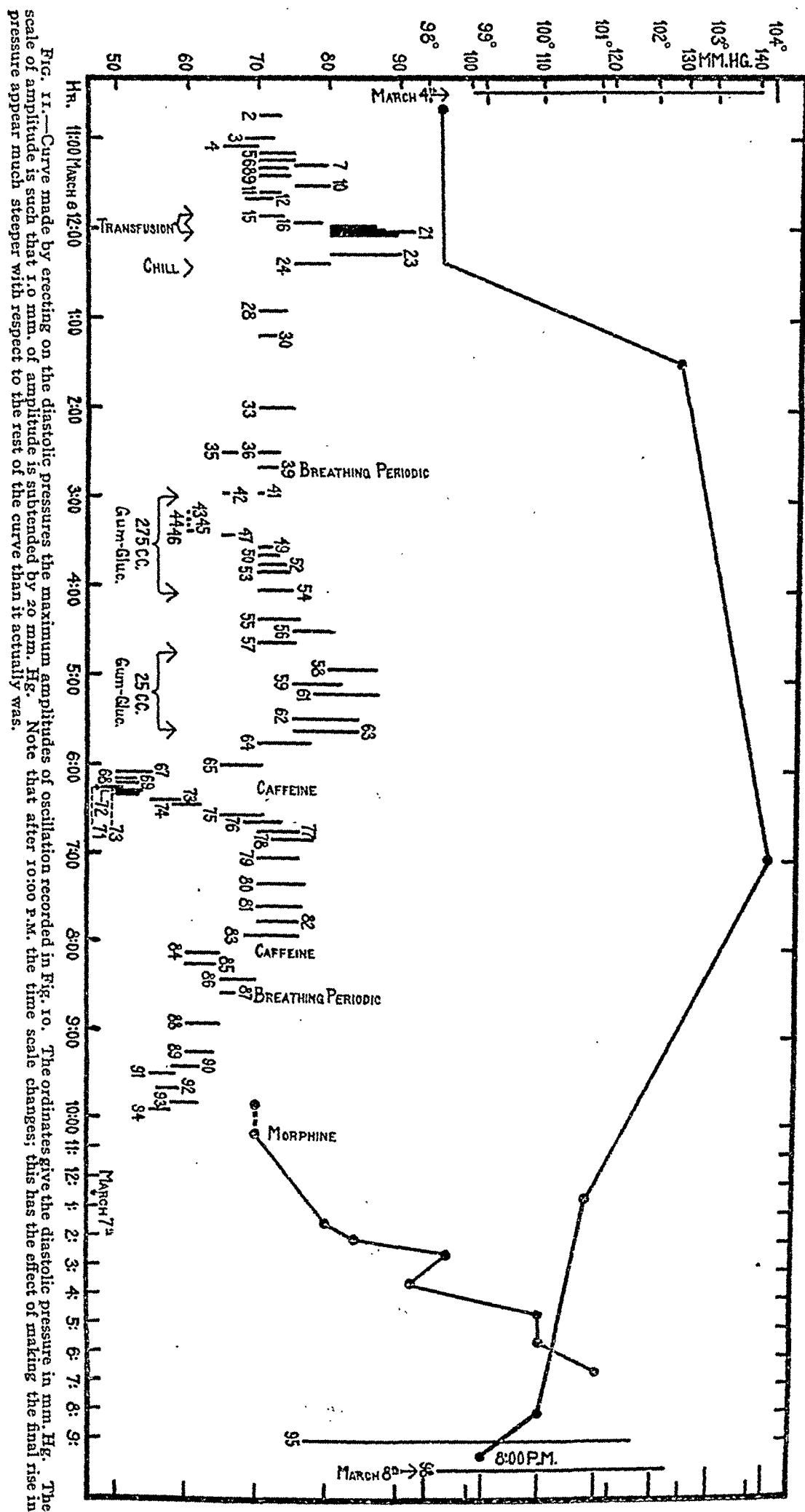
At 11.53, when her pulse pressure had decreased to 10 mm. Hg and the recorded pulse amplitude was decreasing, a second transfusion of citrated blood, taken from a matched donor, her son, was begun. In the course of ten minutes the patient received 450 c.c. of blood. During the injection (records 15–21) the pressures rose to 110, 80 mm. Hg, the amplitude becoming 6 mm. These pressures, however, did not hold. Within twenty-one minutes (record 24) they had fallen to 90, 75; the

amplitude to 2.5 mm.; and the pulse was 180 per minute. The patient now had a chill which for some time interfered with the obtaining of blood-pressure readings. Her temperature, which had been normal, at 1:30 was 102.4° F., at 7 P.M. 104°, and at 10 P.M. 100.8° (see Fig. 11). After the chill the recorded pulse amplitude diminished, to all intents and purposes, progressively (records 28-42) until, by 2.58 (record 42), the recording lever showed only the faintest oscillation on a diastolic pressure of about 65. The respirations now were 38 per minute and often periodic; the skin wet and cold. The patient was completely unconscious; there was no corneal reflex and no reaction to incision of the leg for the purpose of exposing the vein.

The injection of gum-glucose solution was started at this time. In the course of one hour eight minutes she received 275 c.c., when, on account of a leak in the vein, the injection was temporarily discontinued. During the injection the diastolic pressure rose (records 43-54) from 60 to 70 mm. Hg, the systolic to 105, the recorded amplitude increasing from practically nothing to 2.5 mm. The patient regained consciousness and did not again lose it. Later (4.45-5.37) the injection was completed. The total dose amounted to 300 c.c.; but the amount given after 4.05 was so small and the rate of its administration so slow that to all intents and purposes 4.05 marks the end of the injection. From about 3.25 (record 47) and until 5.37 (record 63) there was a progressive improvement in the circulation, the amplitude of oscillation and the pressures becoming quite as good as during the twelve-minute period of rapid blood injection. This improvement occurred despite the concurrent reaction to the blood injection. But now, during the height of the temperature reaction, the pressures fell (records 63-71), reaching the low point of 48 mm. Hg (diastolic) at 6.15. At this time the recorded amplitude was 1.6 mm.; it was not nearly so small as it had been during the period of low pressure that developed after the blood injection. Now the circulation began to improve again (records 71-83), so that by 7.55, the pressures had risen to 100, 70, the amplitude to 3-4 mm. The pulse-rate was 148; the respirations, 32. This improvement again was succeeded by a recession, the pressures, by 9.55 P.M., falling (records 84-94) to 70, 55, the amplitude to 1.5 mm. Periodic respirations were again noted.

During the remainder of the night systolic blood-pressure readings were made by the nurse by the palpatory method. Checked against the readings by the recording sphygmomanometer the former were about 10-15 mm. Hg too low. Bearing this in mind, it becomes obvious (see Fig. 11) that a slow and steady improvement in the circulation began within two to three hours of the termination of my readings, the systolic pressure rising from 70 at 10.30 P.M., March 6, to reach 118 at 6.30 A.M., March 7. At 8.40 A.M. readings with the recording sphygmomanometer (new adjustment of arm band, records 95-97) showed pressures of 120-130 (systolic), 70-80 (diastolic) and a pulse amplitude of 23 mm. The circulation evidently had become normal and it remained so. The patient's temperature reached normal on the third day, and remained normal for twenty-four hours; her pulse-rate remained at the high

GUM ACACIA AND GLUCOSE IN SHOCK



level of 120-130. On March 9 jaundice was first noted; this was disappearing on the 11th. Whether or not the patient had hæmoglobinuria cannot be positively stated, for the urine was voided involuntarily for several days. The nurse, however, states that the urine was dark brown in color.

The curve constructed by plotting the oscillation amplitude on the diastolic pressure (Fig. 11) clearly shows the three long blood-pressure waves, with troughs at 3.10, 6.08 and 9.40, respectively. Without doubt the circulation was at its worst during the first of these troughs. This is indicated both by the mental condition of the patient (consciousness was lost during the first fall only) and by the amplitude of oscillation (the patient actually was pulseless). It was at this time that the gum-glucose solution was given. In the second trough the blood-pressures fell lower than in the first, but the oscillation amplitude remained considerably larger. The latter is a matter of some significance, since, in general, the oscillation amplitude is a relative measure of the amount of blood put out by the heart per beat, and, therefore, of the blood flow. In this trough the patient received a dose of caffeine. One might be inclined to attribute the subsequent improvement in the circulation to the action of this drug were it not for the fact that a second dose of caffeine, given at 8, did not stay the fall in pressure which then was under way. The third trough was not as deep as the second, while the pulse amplitude in both was the same. It was from this trough that the arterial pressure steadily rose to reach normal in the course of about nine hours.

The etiology of these troughs is quite obscure. The only suggestion that seems to have any degree of plausibility refers them, not to anything that was being done at the time, but rather to some effect of the cerebral decompression upon the medullary centres. The fact that the patient at times had Cheyne-Stokes respiration, possibly lends some support to this view. Leaving these sharp depressions out of consideration, examination of the general trend of the curve (Fig. 11) shows that the blood transfusion was quite ephemeral in its effects. The gain was quickly lost and for three hours subsequently the pulse amplitude steadily declined; there is no question but that the circulation was insufficient to sustain life. The gum-glucose solution caused the circulation to improve for about two hours; then, again disregarding the (presumably) fortuitous troughs the circulation slowly but steadily declined through a period of over four hours; but at the end of this decline the circulation was not any worse, at least as regards pulse amplitude, than it had been forty minutes after the blood transfusion nine hours earlier. Then the final turn for the better occurred. It is possible that the waning of the reaction to the blood transfusion, as indicated by the fall in temperature, here facilitated the recovery of the circulation. There can be no question but that the gum-glucose solution markedly improved the circulation. We are inclined to believe that it tided the patient over her critical post-operative period, which was also the period of her reaction to the transfusion.

GUM ACACIA AND GLUCOSE IN SHOCK

The results of the blood examinations, taken from the history, are given below in tabular form. The hæmoglobin estimations are somewhat more consistent than the red cell counts. We, therefore, base our discussion upon the behavior of the former alone. If we leave out of consideration, as being difficult of evaluation, the influence of the blood transfusions and of destruction and regeneration of red-cells, and regard the dilution of the blood as an index to the restoration of the blood-volume, it seems justifiable

Date	R. B. C. per mm. ³	Leuc. per mm. ³	Hb. per cent.
February 28.....	4,432,000	11,800	85
March 4.....	3,424,000	15,600	76
March 6.....	2,048,000	6,100	56
March 7.....	2,496,000	.....	49
March 8.....	1,798,000	.....	43
March 9.....	1,504,000	20,150	39
March 11.....	1,728,000	16,850	40
March 12.....	1,776,000	.....	42
March 13.....	1,952,000	15,000	42
March 14.....	1,964,000	16,700	42
March 15.....	1,620,000	12,400	36
March 16.....	1,760,000	11,800	37
March 18.....	1,824,000	12,500	41
March 19.....	1,312,000	9,750	38
March 20.....	2,048,000	9,980	38
March 21.....	2,853,000	10,500	20
March 22.....	2,240,000	8,750	23
March 22.....	1,744,000	14,950	42
March 23.....	2,112,000	16,080	25
March 24.....	.....	29,450	..

to infer that with the first hemorrhage (March 3) the patient lost about one-ninth of her total blood-volume, and with the second hemorrhage (March 6) a bit less than one-half of the blood-volume remaining. In the two hemorrhages considerably more than one-half of the total blood-volume was lost. The count of March 6 was made about twelve hours after the second hemorrhage and shortly after the administration of the gum-glucose solution. It shows that considerably more than 57 per cent. of the blood-volume finally attained had by then been acquired. Just how much of this rapid restoration of blood-volume is to be attributed to the action of the gum-glucose solution and how much to natural processes it is impossible to say. Nucleated red cells were found March 8.

On the fourth day the patient's temperature started on a more or less steady rise and reached 102°-103° on the eleventh day, where it remained until the nineteenth day. At, or shortly after, the time the temperature began to rise, a badly infected sore developed on the patient's buttocks; by the thirteenth day this had broken down; and on the sixteenth day it had to be incised. On the thirteenth day some sero-sanguinous fluid was removed from the wound in the leg from which the piece of muscle, used to stanch the hemorrhage from the longitudinal sinus, had been removed. On the twentieth day a small area of the patient's scalp was found to be sloughing. A blood culture, made on the

fourteenth day, proved negative. A thorough physical examination seemed to exclude all of the common causes of the febrile condition excepting the skin infections and the anæmia, which had persisted despite the administration of iron. The convulsions, which had been a part of the patient's pre-operative clinical picture, persisted after the operation.

On the nineteenth day the patient, now in an extremely weakened state, was again transfused with blood taken from a rematched donor, again a son. The temperature rose immediately to 106° , fell to 101° eight hours later, and then rose steadily to reach 106.8° in three days, when the patient died, twenty-two days after the second operation. There was no autopsy.

CASE XI.—*Excision of endothelioma of the dura; shock (?)*. White, female. During the excision of the tumor, under ether anæsthesia, the patient's systolic pressure, taken from the leg by the auscultatory method, fell from 160 to 92 mm. Hg, and then could not be estimated at all. There had been relatively little hemorrhage. At this time the diastolic pressure, taken in the leg by the oscillatory method, was 75 mm. Hg, the systolic pressure could not be determined (records A to E, Fig. 12). Records F to I were taken from the arm while the patient was still in the operating room. The diastolic pressure was 70, the pulse amplitude 1.0 to 1.5 mm. Records 1 to 4 were taken between 12.12 and 12.18, after the patient had been put to bed (readjustment of arm band). The diastolic pressure was still 70 and the pulse amplitude 1.5 mm.

I felt that the patient's condition was not urgent and that it would do no harm, before interfering, to determine her trend. But in view of the results of treatment previously observed, the surgeon requested that the gum-glucose solution be given at once. At 12.18 the needle was inserted into the vein transcutaneously and the injection started, but as the fluid seemed to be going into the tissues, the injection was discontinued after about 50 c.c. had left the bottle. At 12.30 the injection was started again, now, into the exposed vein. The pressure and the pulse amplitude had not changed in the interval. In the course of an hour, 212 c.c. more of the solution were injected. During this time (records 5 to 16) the pulse amplitude increased steadily until it became 4 mm. The diastolic pressure rose to 80. The systolic becoming legible at 90, at 12.38, increased steadily and reached 110 at 1.31. The blood-pressure readings made after terminating the injection were as follows:

Record No.	Time	Syst. mm. Hg	Diast. mm. Hg	Max. ampl. mm.
18	1.35 P. M.	115	85	3.5
19	2.00 P. M.	110	85	3.0
20	2.20 P. M.	115	88	3.4
21-22	3.50 P. M.	105	75	3.5
23-24	5.20 P. M.	110	80	4.0
25-27	8.00 P. M.	125	90	5.5
28-29	9.00 A. M.	115	85	6.0 arm band readjusted



FIG. 12.—Blood-pressure records of Case XI. Reduced $\frac{1}{4}$, approximately. Read from left to right and from below upwards. Description in text.



FIG. 13.—Blood-pressure records of Case XII. Reduced $\frac{2}{5}$. Read from left to right and from below upwards, as numbered. Description in text.

GUM ACACIA AND GLUCOSE IN SHOCK

These readings show very slight, if any, retrogression during the first two hours or so, and then a steady improvement.

The patient's temperature rose gradually to reach a maximum of 102.6° at 8 P.M. on the first day. It remained there for about twelve hours, then slowly and steadily fell, and became normal on seventh day. The slow defervescence indicates that the rise was not in the nature of a reaction to the injection.

CASE XII.—*Operation for sarcoma of the uterus; hemorrhage; shock (?)*. Colored, female. The operation consisted in the partial removal of a huge sarcoma of the uterus, which seemed to be aggravating a mitral regurgitation and to be causing, or aggravating, a marked renal insufficiency. During the operation an infected ovarian cyst was accidentally ruptured. There was considerable hemorrhage. I was called to see the patient during the operation, when her pulse could no longer be felt nor her pressure determined (auscultatory method). Records 1 and 2 (obtained at 9.25 A.M.) showed the pressures to be 75 (systolic) and 50 (diastolic); the amplitude was 4.5 mm. (Fig. 13). Twelve and fourteen minutes later (records 3 and 4) the pressures were 65, 50 and 60, 45, respectively, the amplitudes, 3.5 and 4.0 mm.

Again I felt that it would do no harm to follow the trend of things before interfering, but the surgeon requested that the gum-glucose solution be given. Between 9.40 and 10.50, 210 c.c. were administered. The pressures (records 4 to 14) improved promptly, and more or less steadily, so that when the injection was terminated they were 105, 80, and the pulse amplitude 10.5 mm. About a half hour subsequently the pressures fell somewhat to reach 85 and 65, but the amplitude diminished very slightly, to 9.0 mm. (record 20). They then improved so that by evening (arm band readjusted) they were 100, 5 mm. Hg and 8.5 mm. The next morning (readjustment of arm band) they were 105, 76 and 10.0 mm. The pre-operation pressures had been 104, 70. Despite an unabated renal insufficiency indicated by 83–86 mgr. non-protein nitrogen per 100 c.c. blood, and by a phenolsulphone-phthalein output of only 5 per cent. in two hours, the patient made perfect progress for 21 days, when she contracted pneumonia and died on the 25th day. At autopsy a fresh lobar pneumonia and very marked hydronephrosis were found.

Cases of Cholera Infantum.—The two following cases are included in this paper, not because they bear on the treatment of shock, but because they furnish valuable evidence of the harmlessness of the gum-glucose solution. The reasons for administering the solution will probably be published in due time. These cases were not seen by the author. They were in the service of Dr. W. McK. Marriott to whom we are indebted for the following note:

“We have injected the 18–25 per cent. glucose-acacia solution into two infants suffering from alimentary intoxication (cholera infantum). Both were in a state of collapse with feeble pulse, gray skin, great desiccation. The clinical results were good. One of these infants at the time of injection

was in a semicomatose state. He became conscious shortly after the injection. In both instances there was a distinct change in the character of the pulse. From a weak, thready pulse, it changed to a full one. One of these infants had previously received a glucose solution with good effect; but the effect was not so lasting as that of the glucose-acacia mixture. One child received approximately 5 c.c. of the solution per kilo of body weight, the other between 10 and 15 c.c., the solution being injected slowly over a period of some 50 to 65 minutes. No ill effects were observed. The infant receiving the larger amount of solution developed a slow, deep respiration which persisted for several hours after the administration of the solution. This respiration was not due to acidosis as was shown by laboratory tests."

We call attention to the fact that one of these cases received inadvertently more than twice the usual dose without ill effects.

SUMMARY OF CASES.—All ten of the cases treated by the author (see

TABLE V
SYNOPSIS OF CASES

Case No.	Nature of trauma	Condition immediately before	Dose		Immediate result	Ultimate result
			Amt. g.c.c.	Rate c.c.		
				K. hr.		
I.	Crushed foot.....	S., ? D., 40; P. A., 1.3	0	...	Not treated.....	Died in about 4 hours.*
II.	Gunshot wounds. Hemorrhage	S., 80; D., 70; P. A., 1.5	270	2.2	S., 120; D., 80-85; P. A., 5.5. Circ. seems normal	No retrogression. Discharged well.
III.	Panhysterectomy. Hemorrhage. Infection	S., ? D., 30; temp. 105.6; P. A., 1.0—	200	3.2	S., 80; D., 50; P. A., 2.0+. Slight improvement (?) Temp. 106°	Died in 6 hours†
IV.	Splenectomy. Primary carcinoma of liver. Primary and secondary hemorrhage	S., 100; D., 80; P. A., 2.5-2.8	200	1.9	S., 110; D., 80-85; P. A., 5.0-5.5. "Patient rallied"	Slight recession, then improvement. Next day, S., 120; D., 80. Continuous secondary hemorrhage. Died 4th day
V.	Compound comminuted fractures. Fat embolism (?)	Pressures unobtainable	205	3.0	S., 90; D., 65.....	Died in 10½ hours†
VI.	Intestinal obstruction	S., 90; D., 80; P. A., 1.3	200	2.6	S., ? D., 75-80; P. A., 4.0	Pressures not followed. Died in 10½ hours†
VII.	Cerebral exploration. Hemorrhage	Pulse imperceptible. S., very low; D., 75; P. A., 0.5-3.0	250	4.2	S., 100; D., 78; P. A., 4.0. Circulation much improved	No retrogression. Recovered
VIII.	Kraske operation for carcinoma of rectum. Hemorrhage	S., ? D., 58; P. A., 0.3. "Respiration jerky and shallow"	220	2.2	S., 100; D., 78; P. A., 3.5. Circulation much improved	No retrogression. Peritonitis on 4th day. Died on 14th day
IX.	Vaginal resection of cervix. Profuse primary and secondary hemorrhage	Almost pulseless. Pressures undeterminable. P. & A., 0+	...	...	Not treated.....	Died in about 3 hours*
X.	Excision cranial osteoma. Extreme hemorrhage; transfusion reaction	S., ? D., 60; P. A., 0+ Unconscious	300	?	S., 105-110; D., 70-80; P. A., 7.5-12.0. Conscious	Circulation normal after periodic falls. Persistent anemia. Skin infection; died (after transfusion), 22nd day
XI.	Excision dural endothelioma	S., ? D., 70; P. A., 1.5	262	4.0	S., 110-115; D., 80-88; P. A., 4.0; circulation improved	Slight, temporary retrogression. Well
XII.	Excision sarcoma, uterus. Hemorrhage	S., 50; D., 45; P. A., 3.5-4.0	210	4.0	S., 105; D., 80; P. A., 10.5. Circulation good	Slight retrogression in pressures, not in P. A. Died 25th day.

Abbreviations: S.=systolic pressure; D.=diastolic pressure; P. A.=maximum oscillation amplitude.

* After being called to hospital.

† Timed from beginning of treatment.

GUM ACACIA AND GLUCOSE IN SHOCK

Table V) showed a greater or less immediate improvement in the circulation as a result of the administration of the gum-glucose solution. But in three of the cases (III, V, VI) the improvement was by no means satisfactory at the conclusion of the treatment and did not hold. These cases behaved very much like animals in deep experimental shock, in which the injection temporarily raises the pressure though death is inevitable. Of these three cases, one (III) was a case which undoubtedly was overwhelmed by an infection dating from the operation; the second (V) was a case of compound comminuted fracture of both legs and might have been complicated by fat embolism; while the third (VI) was a case of long-standing intestinal obstruction, which might have been complicated by a general infection, by peritonitis or by toxæmia. All three died within twelve hours after beginning the treatment.

The circulation of Case X was improved much more by the gum-glucose injection than by the blood transfusion, but a considerable fall occurred after the injection of the gum-glucose before the circulation became normal. Subsequently, she had an extreme anæmia and a skin infection to contend with. Death occurred on the twenty-second day after a severe reaction to a blood transfusion. In the remaining cases, six in number (II, IV, VII, VIII, XI, XII), the improvement in the circulation that occurred during the injection held or continued subsequently; they, as well as Case X, recovered from the circulatory disturbance and from shock. The fact that the main improvement occurred during the treatment furnishes presumptive evidence that the latter was the cause of the recovery. A much larger series of cases than we have thus far succeeded in collecting, though, is necessary to prove this beyond peradventure.

Of the seven cases that recovered of shock, or of a condition approximating shock, four died subsequently—Case IV on the fourth day, of secondary hemorrhage; Case VIII on the fourteenth day, of peritonitis; Case X on the twenty-second day, probably of anæmia and skin phlegma, aggravated by a reaction to blood transfusion, and Case XII on the twenty-fifth day of lobar pneumonia and hydronephrosis. These deaths unquestionably were due to causes that were not referable to, or influenced by, the treatment. Seven of the cases (II, III, IV, VII, VIII, X and XII) were complicated by hemorrhage, which, in one case (X), was extreme.*

Two cases that might have received treatment did not; one (Case I) because of an accident to the solution; the other (Case IX) because it was decided that blood transfusion was the preferred treatment, and unavoidable delays resulted in the unfortunate failure to give any intravenous treatment at all. These patients died in about four and three hours, respectively, after I had been called to see them. Although we realize how difficult it is to gauge shock, we feel that the condition of Case I when first seen by us was not any worse than that of some of the cases that received treatment. It is also

* NOTE.—(At time of proofreading.) We have had another case of marked shock, with very satisfactory results. Up to now (eleventh day) the patient has made normal progress.

turbance of shock should not withstand the test of time, and even if the theoretical reasons for using glucose or gum acacia should prove wrong, there would still remain the empirical tests which show definitely that the gum-glucose solution saves a certain number of animals from death by trauma. The results obtained through the use of the solution in the treatment of shock-like states in man, and after hemorrhage, are not so easily interpreted as are those of the animal experiments. But they show conclusively that the solution is innocuous and they are strongly suggestive, to say the least, of beneficial action.

We here desire to express our thanks to the surgical staffs of the Barnes Hospital and the St. Louis City Hospital, and especially to Dr. Ernest Sachs, Associate Surgeon, acting in charge of the surgical service of the former, and Dr. Ellis Fischer, Associate Surgeon in the Washington University Unit of the latter, who have made this investigation possible by keeping us informed with regard to, and by placing at our disposal, the clinical material suited to our purposes.

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EXPOSURE IN GALL-BLADDER SURGERY

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A REVIEW of the literature on the subject of surgery of the gall-bladder makes it self-evident that the members of the medical profession have not all been of the same mind with regard to it. Early discussions all related to the desirability of removing or of merely draining the gall-bladder. This contention is now fairly well settled, and the cases are few in which it is believed that the patient's best interests are served by a simple drainage operation. It must be admitted that cholecystostomy, in the hands of the casual operator, is a much easier and safer operation than cholecystectomy, but no one should attempt to remove gall-stones who is not also able and prepared to do any operation on the biliary tract that may be found necessary. We all know how often complications are found when they are least expected, such as stones in the common duct or even fistula between the gall-bladder and other organs.

Specific indications for the removal of the gall-bladder or for drainage have been thoroughly discussed in medical journals in this country, and the list of indications for removal leaves very little question in the mind of the reader that the right thing to do when in doubt is to remove the organ. The remaining contention, therefore, between surgeons is with regard to the method of removal. A great many believe that removal from the fundus down is the safer procedure, in spite of the fact that the field of operation is more or less soiled with blood during the most important and dangerous part of the operation. I have frequently heard surgeons say that in operating on a thin person with a low-lying liver which is easily rotated into the wound, and with the field of operation practically outside the abdomen, it is a simple matter to remove a gall-bladder by first cutting the cystic duct, but that they would like to see it done in a really difficult case, such as that of an acute gall-bladder in an obese patient with a low costal arch.

My own training has been almost entirely in doing cholecystectomies from below up.³ I believe that I have had my share of experience in the emergency and acute varieties of cholecystitis with all the added handicaps of obesity and immobile livers, and I am satisfied that with the exposure it is possible to obtain in every case, the rational operation can be safely performed.

To be able to utilize all the exposure possible is, to my mind, an important consideration in surgery. I have never seen a surgeon in trouble while doing a thyroidectomy if he had the maximum amount of exposure, and we can all recall our occasional difficulties when attempts have been made to remove an appendix through a button-hole incision;

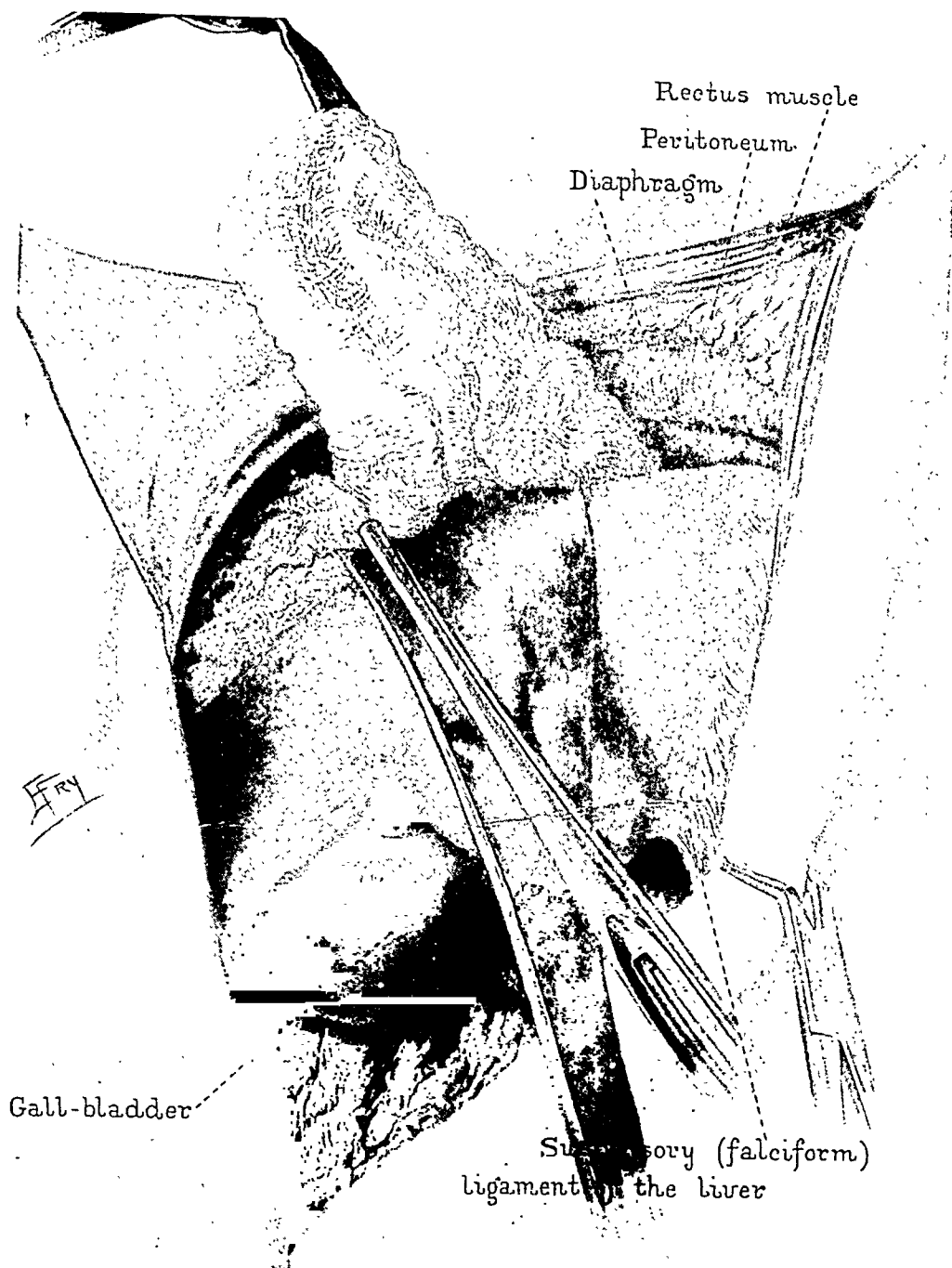


FIG. 1.—Inserting pack between liver and diaphragm.



FIG. 2.—Final exposure, showing flattening of visceral surface of liver.

EXPOSURE IN GALL-BLADDER SURGERY

this is also true in operations on the biliary tract. A method that I have used during the past year, which helps in the more difficult cases to visualize the neck of the gall-bladder, the cystic duct and artery, and also their relations to the common duct and the duodenum is as follows:

Technic.—The abdominal incision extends from the midline at the tip of the ensiform to a point about two inches external to the umbilicus. If it is necessary to remove the appendix the incision may be extended downward, especially if there is an excessive amount of subcutaneous tissue. When not contra-indicated the usual exploration is made. The stomach, large bowel, omentum and small intestine, are separated from the field of operation by three or four abdominal sponges, held in place by the left hand of an assistant. It is important when once the sponges are in place that the assistant should not move this hand during the operation. In almost all such cases this exposure is all that is needed, even when the right lobe of the liver cannot be rotated. In the exceptional case, however, additional exposure is obtained by inserting a pack (4 inches by 3 feet) between the posterior-superior surface of the right lobe of the liver and the diaphragm (Fig. 1). In this manner the liver is made to descend slightly, the concave visceral surface is flattened somewhat, and the hilum of the liver is made more accessible. The insertion of this pack is an easy matter and if carefully placed it can in no way injure either the liver or the diaphragm. With an ordinary abdominal retractor the second assistant retracts the right costal margin upward and outward, while with a long shoe-horn retractor the first assistant gently retracts the liver in the opposite direction. The operator is now able to place the pack in position by using a pair of nine-inch tissue forceps, carrying the gauze along the shoe-horn retractor. Fig. 2 shows the final exposure. I have used this procedure in numerous cholecystectomies, and am satisfied that it has frequently made very difficult cases absolutely safe.

Injuries to the hepatic or common ducts, or hemorrhage, are always avoidable if the operator can see what he is doing and if he proceeds carefully. As anomalies of both ducts and blood-vessels are very common, to know the text-book anatomy of this region is not sufficient.^{1, 2} Absolute knowledge of what is in each forceps before it is clamped is necessary to safety in the procedure.

In cases of large, tense gall-bladders it is often advisable first to empty the gall-bladder with a trocar, and then to apply a six-inch curved forceps to the fundus and another to the ampulla where it overlies the common duct. By drawing on the forceps, especially the last one, the cystic duct is stretched, and by a little blunt dissection with a pair of seven-inch curved forceps, it may be isolated and exposed throughout its entire length. Before cutting this duct the common duct should be palpated; it is much easier to do this now than later, as it can be steadied by traction on the forceps attached to the ampulla. The cystic duct and the artery are secured separately and ligated with plain catgut; care is taken to

occlude the duct close to its juncture with the common bile duct and not to leave a pouch to be a possible cause of future trouble. If the common duct warrants exploration it is preferable to make the incision sufficiently long rather than attempt investigation through the open end of the cystic duct, which is frequently very unsatisfactory. With the mode of exposure as herein outlined, all these procedures may be safely and quickly executed.

I believe that in the future I shall remove very few gall-bladders by commencing at the fundus. I realize, however, that each case must be judged by itself, and that the steps of an operation should not be decided on until exploration has been completed. In the occasional case it may be difficult to expose the cystic duct and artery. I would then advise commencing the removal at the fundus.

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LONG RESECTIONS OF THE INTESTINE

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LONG resections of the intestine are occasionally necessitated by such conditions as extensive gunshot wounds, gangrene and ileocæcal tuberculosis, with multiple strictures. The small bowel varies in length from 15 feet 6 inches to 31 feet 10 inches, the average length being greater in the female. The large intestine varies in length from 3 feet 3 inches to 6 feet 6 inches. People such as the Russian peasantry, who have for generations largely subsisted on a coarse vegetable diet, have longer intestines than those who live on a more concentrated dietary. The removal of the large bowel seems to interfere but little with the bodily nutrition, but after the removal of any considerable length of the small bowel the patient's physiological resources must be very carefully husbanded. Kukula¹ made careful and exhaustive experimental long resections on animals to show by deduction about what proportion of the human intestine could be safely removed.

Both Park² and Moynihan³ have at different times collected all reported cases of long resections of the small bowel, and the total number is not large. It has been rather generally agreed that at least half of the length of the small intestine may be removed, and the patient survives and exists in a fair state of health thereafter. Toombs⁴ mentions a case of long resection in which the cæcum and adjacent small bowel were removed. This patient afterward passed through a typical attack of typhoid fever, indicating that Peyer's patches are not necessarily a focus of the disease. After cutting down the length of the small bowel the wastage of fats and albuminous materials in the nutrient must be very great, and this part of the diet must be increased for these cases.

CASE I.—Adult, male, aged thirty years, weight, 128 pounds. Referred by Dr. D. G. Preston, Burnwell, W. Va.

General History.—Abdominal pain over a period of eight months. Gradual loss of weight and strength; moderate constipation; no attacks of diarrhœa. Pain beginning in the region of the appendix. Occasional vomiting and considerable regurgitation of food for the past two months. Abdomen slightly rigid, visible peristalsis, some abdominal tenderness. Wassermann negative. White blood count, 6800; pulse, 98; temperature, 99 degrees. Small area of dullness in right upper apex.

Diagnosis.—Ileocæcal tuberculosis causing partial obstruction of small bowel.

Operation.—Assisted by Dr. B. S. Preston and Dr. Atlee Mairs,

the following operation was performed January 4, 1916: Right rectus incision about 20 cm. in length. The cæcum was an enlarged mass about the size of a grapefruit. Numerous (eight) tubercular strictures of the small bowel were noted. To eliminate these it was necessary to resort to the radical operation as advocated by Caird⁵ and resect 300 cm. (10 feet) of the small bowel as well as the cæcum and 20 cm. (8 inches) of the ascending colon. A lateral anastomosis was made to the transverse colon. Patient reacted fairly well, but vomiting was quite persistent. Thirty-six hours after the operation it was deemed advisable to reopen the abdomen for the relief of obstruction. Some milky fluid was noted in the right flank. Some of the peritoneal sutures of fine silk had failed to hold. All such points were reinforced with additional silk sutures. A slightly adherent kink was noted in the small bowel, near its junction with the colon. This was straightened out and the contents of the rather distended small bowel were milked into the colon. Two medium-sized rubber cigarette drains were inserted in the wound. In exactly twenty-four hours the patient vomited again, this time a distinctly dark brown vomit. Under novocain-suprarenin anæsthesia an incision was made in the left rectus, a distended loop of small bowel was drawn out and a medium-sized soft-rubber catheter was purse-stringed into this, after the method of Dr. J. W. Long, and brought out through the upper angle of the wound. Bowel contents drained from the tube quite freely. The patient did not vomit again. The tube came away the eighth day. The discharge from the fistula caused some skin excoriation, but the sinus closed in two weeks. After this the patient made an uneventful recovery, and at the end of the fourth week left the hospital by his own request, with his wounds entirely healed. A few days after the operation his bowels began to move, and at first he had an average of six bowel movements every twenty-four hours. This condition gradually improved, and by the time he left the hospital he was having an average number of three movements in twenty-four hours.

After his recovery and discharge from the hospital this patient was exhibited before the Kanawha Medical Society.

X-ray examination by Dr. W. R. Hughey shows a rapid filling of the very limited small bowel, with early entry into the transverse colon, part of the contents regurgitating into the remains of the ascending colon and hepatic flexure.

Later History.—This patient left the city in severe winter weather and visited friends in the mining regions near by. During this time he celebrated by getting drunk. A few days later he returned to Charleston, suffering from a very severe cold. He rapidly became worse and developed the symptoms of an acute tuberculosis of the lungs. He reëntered the hospital February 23, 1916, and on February 28, 1916, died.

Postmortem examination made by Drs. M. I. Mendeloff, H. D. Hatfield and the writer. The abdomen was opened by a long, median incision. With the exception of a few adhesions in the location of the former drainage tubes, the intestines were in excellent condition. The anastomosis was as smooth as if it had existed for years. There were no visible signs of visceral tuberculosis. The few palpable mesenteric glands that were present at the time of the original operation had disappeared. The small intestine up to the duodenojejunal junction was measured and found to be only 5 feet 7 inches in length. Of the large bowel there were 4 feet 9 inches.

Fantino⁶ suggests that in cases of extensive resection a vicious circle should be established in the remaining segment of bowel in order that the intestinal contents may circulate long enough to complete the digestive and assimilative processes.

Turck⁷ says: "A review of the literature and a study of case histories point plainly to the fact that, from a viewpoint of ultimate results, short-circuiting, whenever possible, is much to be preferred to resection, particularly if the lower ileum is involved. In the case reported above, while circuiting was decided against at the time of operation because of the indescribable adhesions, the foul sinuses and fistulous tracts, it is probable that a better ultimate result would have been attained had the worst segments been removed, and the remaining adherent gut short-circuited in one or two places. This patient certainly has not enough small intestine to permit of thorough absorption, though compensatory intestinal hyperplasia provided adequate digestion."

Henson⁸ in his report on Turck's case says that with the usual hospital diet the patient had about six stools per day. He was then given astringent and digestive ferments, but these had no effect whatever on the number of stools.

Henson's summary is so complete that it is quoted along with his tables.

The following table shows the average number of stools per diem under a variety of restricted diets:

Special Diet	Average Number of Stools per Diem
Chicken, roast beef, toast and cereals	5.00
Oatmeal, sugar and milk	4.25
Irish potatoes, oatmeal, sugar and milk	4.00
Regular hospital diet excluding all meats	3.66
Hospital soft diet	3.00

"The fæces were examined after having been on the regular hospital diet for several days, resulting in the following findings:

"Stool, fluid; quantity, 700 grams; color, light yellow; odor, not especially offensive. Reaction, acid to both litmus and phenolphthalein. Chemical tests for starch,

erythrodextrin, sugar, and occult blood were all negative; for mucin, only slightly positive.

The stool macroscopically showed a moderate lientery, which, upon microscopic examination, was found to be due to an azotorrhea. The fibers were mostly digested to the point that the transverse striations and nuclei were not shown, but in some both longitudinal and transverse striations could be observed. Steatorrhea not present, nor were crystals of any form in excess.

"The patient was then placed upon the following diet:

	Grams.	Albumin per cent.	Fat per cent.	Hydrates per cent.	Calories
Zwieback.....	100.00	8.00	1.00	75.00	349.60
Toast.....	200.00	14.00	1.00	110.00	517.70
Potatoes.....	192.00	2.60	.....	38.40	168.10
Eggs (4).....	.....	28.20	22.00	.....	320.92
Butter.....	30.00	.....	23.00	.....	214.66
Cream.....	128.00	4.62	34.24	4.50	356.96
Milk.....	256.00	8.96	6.40	9.98	137.37
Sugar.....	40.00	.14	.....	37.33	164.00
	946.00	66.52	87.64	275.21	2,229.31

"Weight of patient, 63 kilos; 35 grams to kilo equals 2205, equals required calories at rest.

"It is worthy of note that during all preceding periods in which his urine was examined for indican this constituent was constantly and markedly in excess, but that two days after being on the foregoing diet the indicanuria almost entirely disappeared. While on the diet tabulated his average urinary output was 456 c.c. per diem, the specific gravity of a twenty-four-hour specimen was 10.28, the total urea output in the twenty-four hours was 7.84 grams. His stools following the use of this diet averaged three per diem. The feces within a short time became semiformal with an average weight of 755.2 grams. There were no chemical or microscopic findings different from what has already been recorded while the patient was on the regular diet, with the exception, of course, that the azotorrhœa was not present. Further tests for starch, erythrodextrin and sugar were all negative.

"In this case it would seem probable that a compensatory hyperplasia of the small intestine and a compensatory production of the ferment enterokinase was at least commenced. We know that amylopsin and steapsin are capable of exercising their functions with little auxiliary aid from this ferment. It is reasonable, therefore, to presume that the compensatory production of enterokinase in this patient has reached the point where, together with the enzymes of the pancreatic juice, it is sufficient to digest pretty thoroughly the intake of carbohydrates and fats, but that this compensatory production has not reached the point of thoroughly digesting proteids.

"For the purpose of demonstrating to what extent the absorbability of the intestine is interfered with, Sahli's method was tried, the patient being given 0.15 gram iodoform in a salol-coated gelatin capsule with an Ewald test meal. The appearance of the iodine reaction in the saliva on two different occasions was delayed six hours, hourly tests being conducted."

I append a table of cases taken in part from Park, Moynihan and other sources, and relatively taken up to date.

LONG RESECTIONS OF THE INTESTINE

TABLE OF REPORTED CASES OF LONG RESECTION OF INTESTINE

Operator and reference	Length of section of intestine resected	Result
Schlatter: Kor.-Bl. f. Schweiz, Aerzte, 1899; Beiträge z. klin. Chir., 1906, xlix, i; Lancet, 1900, i, 207	192 cm. after "considerable shrinking" subsequent to removal.	Recovery
Boeckel I: Bull. de l'Acad. de med., Paris, 1912, lxxviii, 241	200 cm.	Recovery
Lexer: Berl. klin. Wchnschr. 1900, xxxvii, 4; Albu: Berl. klin. Wchnschr., 1901, No. 50	200 cm. small intestine.	Recovery
Peterson: Ref. Rusch-haupt., Inaug. Diss., Bonn, 1901	202 cm.	Recovery
Flint, J. M.: Johns Hopkins Hosp. Bull., 1912, xxiii, 127	204 cm. collapsed	Death six days later
Reder, Francis: Personal communication.	204 cm. ileum	Recovery
Koeberle: Centralbl. f. Chir., 1881, viii, 249	205 cm. small intestine	Recovery
Myaki: Arch. f. klin. Chir., 1910, xciii, 708	206 cm. resected	Death 4 days later of septic peritonitis
Enderlin; Ref. Lauenstein: Deutsche Ztschr. f. Chir., 1909, c, 169	207 cm. resected	Recovery
Kocher, quoted by Trzebieky: Arch. f. klin. Chir., 1894, xlviii	208 cm. small intestine	Recovery
Mikulicz: Rothe, Beiträge z. klin. Chir., 1902, xxxiii, 140	215 cm.	Recovery
Dreesmann: Berl. klin. Wchnschr., 1899, xxxvi, 337	215 cm. ileum	Recovery
Axhausen: Mitth. a. d. Grenzgeb. d. u. Chir., 1909, xxi, 55	215 cm.	Recovery
Karlow: Hygeia, No. 3	215 cm. small intestine	Recovery
Thon: Deutsche med. Wchnschr., 1909, xxxv, 742	220 cm.	Recovery
Dekonski: Ref. Istomin: Russ. med. Rundschau, 1910, viii, 329	220 cm.	Recovery
Kouwer: Nederl. Tijdschr. v. Geneesk., Amst. 1898, 2 R., xxxiv, d. 2, 887	224 cm.	Recovery
Shepherd: Centralbl. f. Chir., 1898, xxv, 397	234 cm. ileum	Recovery
Kukula: Arch. f. klin. Chir., 1900, lx, 887	237 cm. ileum	Recovery
Harris: New York Med. Rec., 1902, lxii, 566	239 cm. ileum	Recovery
Kirkwood, W. L.: Medical Journal of Australia, 1915, ii, 49	240 cm. resected	Recovery; abscess; second operation for recurrence of symptoms 9 mos. later. Recovered; well and better than after first
Hayes, quoted by Harris	248 cm. small intestine	Recovery
Brenner and Denk: Wien. klin. Wchnschr., 1907, xx, 1649	250 cm.	Recovery
Enochin: Red. Istomin, Russ. med. Rundschau, 1910, viii, 329	250 cm.	Recovery
Peck, quoted by Harris	251 cm. small intestine	Recovery
Blayney: British Med. Jour., 1901, ii, 1456	255 cm.	Recovery
Lauwers: Ann. de la Soc. de Chir. (de Belge), 1901, ix	265 cm. small	Recovery
Park: Arch. Ontar. de Chir. i, Centralbl. f. Chir., 1904, xxxi, 55; Buffalo Med. Jour., 1903	265 cm. small	Recovery
Payr: Arch. f. klin. Chir., 1902, lxxvii, 181	265 cm. ileum	Recovery
Pokotilo: Chirurgia, 1909, xxv, 169	270 cm. resected	Recovery

JOHN E. CANNADAY

Operator and reference	Length of section of intestine resected	Result
Mitchell: quoted in Kelly and Noble's Abdominal Surgery, Philadelphia, 1908, p. 442	274 cm.	Death
Kopfstein: Revue de Bohm. Med., 1909, Ref. Wien. Med. Bl., 1910	275 cm.	Recovery
Maydi: quoted by Kukula; Arch. f. klin. Chir.	284 cm. ileum and 8 cm. colon	Recovery
Childe: British Med. Jour., 1901, ii, 891; Practitioner, 1909, cxxii, 364	289 cm.	Recovered; lived seven months
Lorenz: Wien. klin. Wchnschr., 1906, xix, 610	292 cm.	Recovery
Goebell: Deutsch. Ztschr. f. Chir., 1905, lxx, 608	300 cm. small intestine	Recovery
Fantino: Riforma med., Naples, 1902, xviii, 181	300 cm.	Death one month after operation
Tombs, quoted by Murphy; Year Book General Surgery, 1915	305 cm.	Recovery
E. Stachlin: Annals of Surgery, 1907, xiv, 49, and personal communication	305 cm.	Recovery
Fantino: Gaz. medica di Torino, 1896, xlviii	310 cm. ileum	Recovery
Monprofit: Rev. di Chir., 1899, xx, 579	310 cm. intestine (230 cm. ileum; 80 cm. large intestine)	Recovery
Ghedini: Clin. Chir., Milano, 1905, xii, 278	315 cm.	Recovered, lived three and one-half months
Zusch: Deutsch med. Wchnschr., 1909, p. 739 (operation in 1896)	316 cm.	Recovery
Fischer, A.: Orvosi hetil, No. 37, 1905; Centralbl. f. d. Grenzgeb. d. Med. u. Chir., 1906, ix, 70	316 cm.	Recovery
Zeidler: Centralbl. f. Chir., 1906	318 cm. ileum	Recovery
Whitall: ANNALS OF SURGERY, 1911, civ. 699; ANNALS OF SURG., 1913, lviii, No. 5	320 cm.	Recovery
Norton: Ref. Kelly and Noble, Abdominal Surgery, Philadelphia, 1908, p. 442	322 cm.	Recovery
Myaki: quoted by Flint; Johns Hopkins Hosp. Bull., May 1912	328 cm., ileum; 225; colon, 13	Recovery
Ruggi: Policlinico, 1896; Centralbl. f. Chir., 1896, xxiii, 365	330 cm. principally ileum	Recovery
McGuire: Surg. Gynec. and Obst., January, 1913	336 cm.	Recovery
F. J. Brougham: Surg., Gynec. and Obst., v. 782	345 cm.	Recovery
Nicola: Clin. Chir., 1910	350 cm.	Recovery
Baracz: Arch. f. klin. Chir., lxxxiii, 478	350 cm.	Death two days after operation
Von Eiselsberg (the case is given by Park, Payr and others, but I can get no further particulars)	350 cm.	Death after twenty-five days
J. W. Long: personal communication	360 cm. ileum	Death
Obalinski: Arch. f. klin. Chir., 1894, xlviii, 16	365 cm. ileum and cæcum	Death in twenty-eight hours
A. Werelius: Jour. Am. Med. Assn., 1907, xlviii, 945	12 feet, 2 inches (365 cm.)	Recovery; button passed on tenth day
Mitchell: British Med. Jour., 1902, ii, 975	366 cm.	Recovery
Turck: New York Med. Jour., 1914, xcix, p. 316	371 cm. ileum and colon	Recovery
W. D. Haggard: Personal communication	380 cm. ileum and cæcum	Death in eleven days
Pauchet: Personal communication; Jahresbericht f. Chir., 1905, xi, 732	400 cm. ileum	Recovery
Friedrich: Med. Klin., 1904-05, i, 25]	400 cm.	Recovery

LONG RESECTIONS OF THE INTESTINE

Operator and reference	Length of section of intestine resected	Result
Stolz: Deutsch. med. Wchnschr., 1909, p. 744	475 cm.	Recovery
Axhausen: Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1909, xxi, 55	475 cm.	Recovery
Storp: Deutsch. Ztschr. f. Chir., 1907, lxxxvii, 322	510 cm. small intestine (the entire ileum and part of the jejunum)	Recovery
Nigrisoli: Atti del. xvi Congr. Ital. de Chir., 1902	520 cm. small intestine	Recovery
Ghedini: Clin. Chir., Milano, 1905, xiii, 278	524 cm.	Recovery
Brenner, reported by Denk: Mitth. a. d. Grenzgeb. d. Med. u. Chir., 1910, Heft i. p. 146	540 cm.	Recovery

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- ³ Moynihan, Sir Berekley: Abdominal Operations, pp. 461-468.
- ⁴ Toombs, P. W.: Railway Surg. Jour., November, 1914.
- ⁵ Caird, F. M.: Scottish Surg. and Med. Jour., xiv, 20.
- ⁶ Fantino, quoted by Turck: New York Med. Jour., February, 1914, p. 318.
- ⁷ Turck: New York Med. Jour., February, 1914, p. 318.
- ⁸ Henson, quoted by Turck: New York Med. Jour., February, 1914, p. 31.

LOTHEISEN'S OPERATION FOR FEMORAL HERNIA*

BY HERMANN FISCHER, M.D.

OF NEW YORK

LOOKING over the literature of operations for inguinal and femoral herniæ the student is struck by the fact that there is almost a complete unanimity among surgeons as to the proper procedure in dealing with an inguinal hernia. Bassini's operation has become the common property of surgeons all over the world; all other methods have been practically abandoned. In the treatment of femoral hernia this happy situation does not obtain. A large number of different methods (over 70) have been invented and advocated from the simple Bassini to the complicated bone-periosteal flap plastics of Trendelenburg and Kraske. The multiplicity of methods alone shows that the problem has not been solved satisfactorily. Although experienced surgeons proclaim that simple closure by suture of the external femoral ring is sufficient, it is a fact that a number of femoral hernias thus operated upon recur early, especially those of large size.

I shall not go into detail as to the different methods proposed. It is sufficient to state that all of the older methods which attacked the problem from the crural side have failed to take into consideration the fundamental anatomical principle involved, *i.e.*, closure of the *internal crural ring* by a *muscle-fascia plastic*.

Some years ago a number of authors chose the inguinal route for the operation of crural hernias (Annandale, 1876; Ruggi, 1898; Parlavecchio, Edebohls, Narath). Tuffier, Lotheisen and Foederl have independently of each other advocated this route and have tried to make it popular among surgeons. Among American surgeons it was Kammerer who introduced the inguinal route here, availing himself of the Lotheisen method (1904). In 1907 Moschowitz published his operation, having used his method first in 1905. The same procedure has been described and highly advocated by Frank in 1909. I personally became acquainted with Lotheisen's operation in 1904, having assisted Doctor Kammerer in a number of cases. I was so favorably impressed by the operation that it has become my method of choice in all cases of femoral hernia that present themselves.

The operation is executed as follows: Skin incision along Poupart's ligament about one-quarter inch above the same, beginning at the pubic spine and ending one-quarter inch within the anterior superior spine of the ilium. Division of the fascia of the external oblique muscle, which is retracted until the border of the conjoint tendon and internal oblique muscle are exposed. The spermatic cord, or the ligamentum rotundum, is

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LOTHEISEN'S OPERATION FOR FEMORAL HERNIA

pulled upward and inward by a small blunt retractor; sometimes the round ligament is small and atrophic and can be ignored. The posterior wall of the inguinal canal consisting of the aponeurosis of the transversalis muscle and transverse fascia is now incised, not near Poupart's ligament, but about one-quarter inch above it. We have now reached the properitoneal space; a few small veins, branches of the epigastric, have to be tied. The next step is to clear away the loose areolar and fatty tissue which overlies the neck of the sac and the femoral vein in order to identify these structures. I make it a point to identify the femoral vein first, which is invariably easily accomplished. The neck of the sac is then found lying close to the inner side of the femoral vein. This latter structure is carefully pulled outward by a blunt retractor. If the sac is small and does not contain omentum or intestines which are adherent, it can easily be pulled out of the femoral canal.

Thus, the femoral hernia has been transformed into an inguinal one. If the sac is large, containing omentum and intestines which are not reducible, I open the sac, reduce its contents and pull the sac out of its bed.

The next step is to identify Cooper's ligament, which is easily done by retracting the conjoined tendon and the properitoneal tissue upward and removing with a gauze sponge the thin areolar tissue covering the pectineus muscle. The ligament will be seen as a white glistening band, covering the ilio-pectineal line. Chromic gut sutures are now put through the muscle shelf and through Cooper's ligament, two or three sutures being usually sufficient. The needles must be small and must have a full curve. Care has to be taken in putting the last suture which comes to lie close to the femoral vein in order not to injure the vessel. The sutures are tied, and thus the crural canal will be shut off close to the femoral vein. Suture of the fascia of the external oblique and skin finishes the operation. After having united the cut in the external oblique fascia, it will be noticed that there exists a small funnel-shaped dead space between it and the sutured muscle. This can easily be obliterated by a good fitting spica exerting a little compression at this point.

In large and strangulated femoral hernias I change my skin incision a little by giving it a downward sweep over the highest point of the tumor below Poupart's ligament and dissecting the skin flap upward. The constricting fibres of Poupart's ligament are then divided from above downward under complete guidance of the eye and with certain avoidance of accidents to anomalous vessels or to the incarcerated contents of the sac. The incised Poupart's ligament is reconstructed by two chromic sutures.

In these cases of *strangulated* femoral hernia in which Poupart's ligament has to be sacrificed, the advantages of Lotheisen's operation over the Moschcowitz-Frank method becomes especially apparent. In the latter method the cut ligament has to be utilized for the plastic closure, and has therefore to bear the pressure of the abdominal contents, whereas

in the Lotheisen operation the strain is entirely transferred from Poupart's ligament to Cooper's ligament. The latter fact can be demonstrated by examining patients after operation in the erect posture. If the patient is made to strain or cough, it will be seen that there is a distinct inward and upward pull of the abdominal muscles above Poupart's ligament, instead of a bulging outward.

I have operated upon thirty-seven cases. Of these twenty-two have been reëxamined. Five cases have been reëxamined after three years, seven cases after five years, three cases after six years, one case after eight years, one case after nine years, five cases after four to five months. None of these patients showed a recurrence.

TRANSPLANTATION OF THE VERMIFORM APPENDIX INTO THE FEMALE BLADDER TO SUPPLY AN ABSENT URETHRA*

By CHARLES M. ROSSER, M.D.

OF DALLAS, TEX.

THE vermiform appendix has had medical and surgical consideration for disorders consequent to its pathological changes for many years, but few attempts have been made for its utilization and fewer in which practical benefit has been derived. The case I am to report does not, of course, answer seriously the question often proposed by the laity, *i.e.*, "what is the appendix for?" but it is of somewhat unique significance that it may be successfully transplanted for a practical purpose.

In the operation I report I was able to employ principles already worked out for the cure of a condition heretofore baffling to the surgeon, of intolerable annoyance to the patient, and in doing so hope to have opened the way to a more successful method of dealing with hypo- and epispadias.

The appendix has been brought through the abdominal wall for drainage and irrigation results, but in this no excision was required. It has been brought down and attached to the uterine cornu to substitute an ablated tube. Dr. Robt. T. Morris has succeeded in such a transplantation both by previous and later cecal severance.

In my case a free transplant of the appendix was made within a prepared tunnel extending from slightly within the neck of the bladder to a point near the clitoris where the normal meatus had been before its destruction.

In October, 1918, Mrs. A. presented herself in my clinic at the Baptist Sanitarium with the following pertinent history. Widow, aged forty-eight, no important clinical conditions except that, for what she had been told was a malignant tumor of the urethra, that organ had been removed at the bladder juncture five years previously. Since that time the bladder was both minus a delivery tube and the power of urinary control. Scar tissue consequent to ancient surgery preceded plastic quilling of the anterior vaginal lining, and a tunnel behind it would certainly ulcerate from urinary travel if passing through, and there was no promise of preventing closure except by an insert of some variety of tissue lining tolerant to frequent contact with kidney excretion.

The appendix seemed to offer only autogenous material meeting both architectural and histological requirements. The operation planned and executed consisted of incisions through the mucosa, one

* Read before the Southern Surgical Association at its annual meeting, Baltimore, December, 1918.

below the clitoris, and the other at the bladder exit between which a tunnel behind the anterior vaginal vault was made with suitable forceps. Mucosa was dissected from inside neck of the bladder for the distance of about three-fourths of an inch. Splitting the mucous membrane over the neck of the bladder longitudinally uncovered the remaining portion of its sphincter so that it could later be narrowed.

These preparatory steps taken, the patient's normal appendix was removed together with its meso and quickly placed in warm saline. While held emersed in this the tip was cut off, its lumen sterilized by injection of 50 per cent. alcohol, and a small-sized catheter passed through it. The meso-appendix was then clipped and several linear incisions made through the peritoneal coat. So prepared, the catheter with the transplant was inserted through the tunnel described well into the bladder, the distal end of the appendix entering the freshened bladder neck about one-half inch, where it was sutured as was the tunnel to bladder with fine catgut. The proximal end projected fortunately half an inch out of the upper end of the tunnel. This made a meatus possible by splitting and sewing the flaps back on either side to a denuded surface. I should add that while suturing the bladder neck to the prepared and transversed tunnel care was taken to restore sphincter action by suturing such neglected fibres as could be found, and that the juncture line was reinforced by pedunculated flaps dissected for that purpose.

For four days the catheter was allowed to remain, the only treatment being daily irrigations with warm boric solution. A protecting silk stitch was then cut, the catheter withdrawn, and the bladder irrigated through the new urethra. The catheter was then replaced for a few days, after which its use was discontinued.

The patient left the hospital in ten days but was under constant observation for several weeks, during which time the bladder behavior was normal, control being perfect, the capacity which had been greatly lessened by the five years of incontinence gradually expanded, and the transplanted appendix accustomed itself to its new surroundings, furnishing what promises to be a permanent and satisfactory urinary canal.

TREATMENT OF STREPTOCOCCUS SEPTICÆMIA COMPLICATED BY WOUND DIPHTHERIA, MAKING USE OF TRANSFUSION OF BLOOD IMMUNE TO THE STREPTOCOCCUS

By CHAS. S. VIVIAN, M.D.

OF HUMBOLDT, ARIZONA

CHIEF among the causes of failure in combating streptococcus septicæmia, by means of the intravenous introduction of antistreptococcic serums, is in all probability the fact that the serum used does not contain specific antibodies for the particular strain of streptococci which is at fault. Being confronted with a severe case of this nature and having this hypothesis in mind, it occurred to me, that the best weapon to use against the streptococcus would be the serum or blood in which antibodies had been produced by vaccination with the organism recovered from the patient's blood stream. Since transfusion of blood by the citrate method is always possible and a vaccine is easily made, it remains only to find a suitable donor. The following case illustrates the scheme of treatment practiced at the Humboldt Hospital:

The patient, a boy of sixteen, always previously healthy, stumbled and fell, while walking along a dirt road in the southern part of this State. He received a laceration of the soft parts of his right thigh about three inches above the knee. This laceration was sewed up and a plaster case was applied to the leg above, including and below the knee. Two days subsequently his temperature rose to 104° F., and continued to reach this point or above for ten days following. He was then taken to California, where an X-ray disclosed the presence of a dog bone, sewed up in the soft parts close to the femur. This was removed and several counter-openings were made to allow for the escape of pus. Notwithstanding that there was free drainage, the temperature continued to rise above 104° F. daily. This continued for two weeks, at the end of which time he was brought to Humboldt, and placed under the care of the writer. Temperature upon admission 103° F. at 4.30 P.M. Smears taken from the wound upon admission on July 5, 1918, showed the presence of streptococci in short chains. The urine contained a rare cellular cast, albumen, red and white cells and the streptococcus. There was no heart murmur. Dakin's fluid was led into the numerous wounds around the knee by means of Carrel tubes and several subcutaneous accumulations of pus were evacuated. He was given 170 c.c. of antistreptococcus serum subcutaneously over a period of about five days, with no effect on the temperature. The knee on July seventh was reported as negative for pus by an X-ray consultant. Blood cultures grew short chained streptococci from which vaccine was prepared on July tenth. A suitable donor, one of the

nurses who volunteered, was given a small dose of vaccine on the tenth, a slightly larger one on the eleventh, and one hundred million organisms on the twelfth, after blood had been taken for transfusion. One hundred cubic centimetres of her blood was given by the citrate method intravenously to the patient. She received two hundred million organisms on the thirteenth, and her blood sent to the laboratory two days subsequently was reported as being strongly antistreptococcic by titration in high dilution. Each dose of vaccine had produced a sharp reaction in the donor. There was no reaction in the patient following the transfusion, until which time his temperature had continued to range between 104° F. and 104.6° F. in the afternoons, swinging down to nearly normal in the mornings. The pulse previous to this time had reached 130 and a mitral murmur had developed. The day after the transfusion, the temperature did not go above 102.5° F., although the pulse remained fast. The next day, however, the temperature was again 104.5° F., which point it continued to reach until the sixteenth, when another transfusion of immune blood was given. More than 100 c.c. were drawn, the intention being to give at least 300 c.c., but it showed a marked tendency to clot, although the same strength citrate solution was used, *viz.*, 290 per cent. The clot was filtered out and the resulting 100 c.c. was all that was given. The transfusion produced an immediate violent reaction, marked by a rigor of forty minutes' duration, followed by a drop in temperature to 96° F. During the next few days the whole picture changed. The patient no longer had the appearance of being desperately ill, his appetite returned, and bed sores which had developed, despite the most scrupulous care, began to take on a more healthy aspect. Blood culture taken on the nineteenth failed to grow the streptococcus and streptococci which had been constantly present in the urine were absent. The ankle-joint, which had previously been swollen, gradually subsided. The temperature was markedly lower, although it still went as high as 102.5° F. and once went above 103° F.

On the tenth of July smears from the wounds showed the presence of the diphtheria bacillus, secured by raising from the incised areas the dirty, gray membrane, which bled upon removal.

Five thousand units of diphtheria antitoxin were given on the tenth, followed by a like amount upon the eleventh. Three thousand units were given on the twelfth, and, after the stock had been replenished, twenty-five thousand were given on the fourteenth, twenty-four thousand on the fifteenth and and twenty-seven thousand on the sixteenth. On the seventeenth twenty-seven thousand units were given, to be followed on the eighteenth by forty-nine thousand units, which concluded the treatment with antitoxin, as culture from the wound had failed to grow the Klebs-Loeffler bacillus. All diphtheria antitoxin was given subcutaneously. The continuation of temperature around 102° F. after both infecting organisms were apparently eliminated seemed to call for more radical drainage to eliminate the pus producing bacteria which were still present in the smears. The question of amputation was raised at

TRANSFUSION OF IMMUNE BLOOD

this time, but it was thought better to delay this measure because of the attendant shock. On the twentieth, under ether, the wounds which were still draining were laid open, and the cavity of the knee-joint was drained by a circular incision which divided all the structures down to the popliteal space. A small amount of pus was seen to drain from a rent in the capsule of the knee-joint and the joint surfaces themselves were found eroded as from arthritis. The leg was flexed on the thigh and a rubber tube was placed in the cavity of the knee, to be replaced by a Carrel tube the next day. The drainage operation had little effect upon the temperature, which continued to rise daily above 102° F. until the twenty-ninth when it gradually fell below 102° F., above which point it was never again recorded.

Blood transfusion was again done on the thirtieth, using this time the boy's sister, who had not been immunized to the streptococcus as donor. There was no reaction but the hæmoglobin rose from 70 per cent. to 80 per cent. Convalescence was very protracted because of the bed sores and because of aseptic thrombosis of the external saphenous vein below the knee which sloughed to the bone. The boy left the hospital on crutches on the first of April, 1919, having a stiff knee and one or two areas still uncovered by skin.

CONCLUSION

Failure to find the streptococcus where it had been previously (*i.e.*, in the urine and blood) after the second transfusion is presumptive evidence that the immune blood had a curative effect.

DOUBLE-EYED ANEURISM NEEDLE

By ANGELO L. SORESI, M.D.

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AT PRESENT SERVING IN THE ITALIAN ARMY, AS SURGEON AT THE OSPEDALE MILITARE PRINCIPALE, MILANO

ALL surgeons have experienced considerable inconvenience when using the common one-eyed aneurism needle, when a double ligature is necessary and the thread has to be divided: the surgeon and the assistant might take and pull the wrong end of the thread which gets twisted and a great deal of time, and temper, is lost in untwisting it.

We will not dwell too long on these inconveniences, as they are too well known to all surgeons, but would like to point out the advantages

FIG. 1

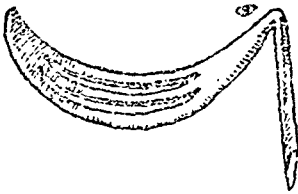


FIG. 2

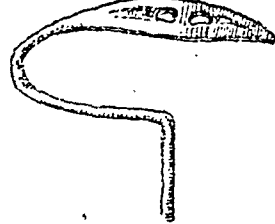
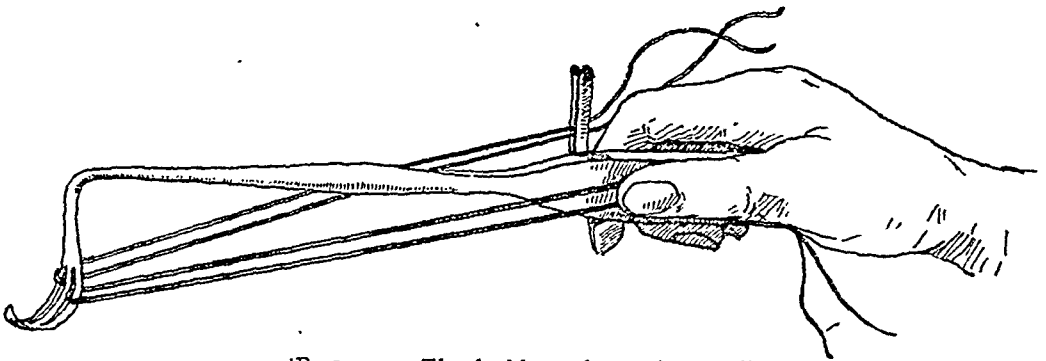


FIG. 3



FIGS. 1-3.—The double-eyed aneurism needle.

of the two-eyed aneurism needle, that we have devised, which are the following:

The two-eyed aneurism needle is exactly the same as the single-eyed one commonly used, and can be made to any pattern the surgeon may wish, the only difference between them being that the needle commonly known has one eye, and the one we wish to bring before the surgeon has two eyes, which eyes can be placed one over the other, or side by side, as shown in the illustration (Figs. 1 and 2).

The double-eyed aneurism needle we show in the illustration has a small spring catch on the handle, which, as explained later, facilitates the work of the surgeon, but that is not indispensable.

DOUBLE-EYED ANEURISM NEEDLE

The method of using the double-eyed aneurism needle is to thread through the outside or the upper hole, a thread about 15 cm. long, the ends of which should be caught in the spring catch placed on the handle. Another thread of about equal length is threaded through the other hole and the surgeon should hold the second thread with his thumb, as shown in the illustration (Fig. 3). After the needle has been passed through the

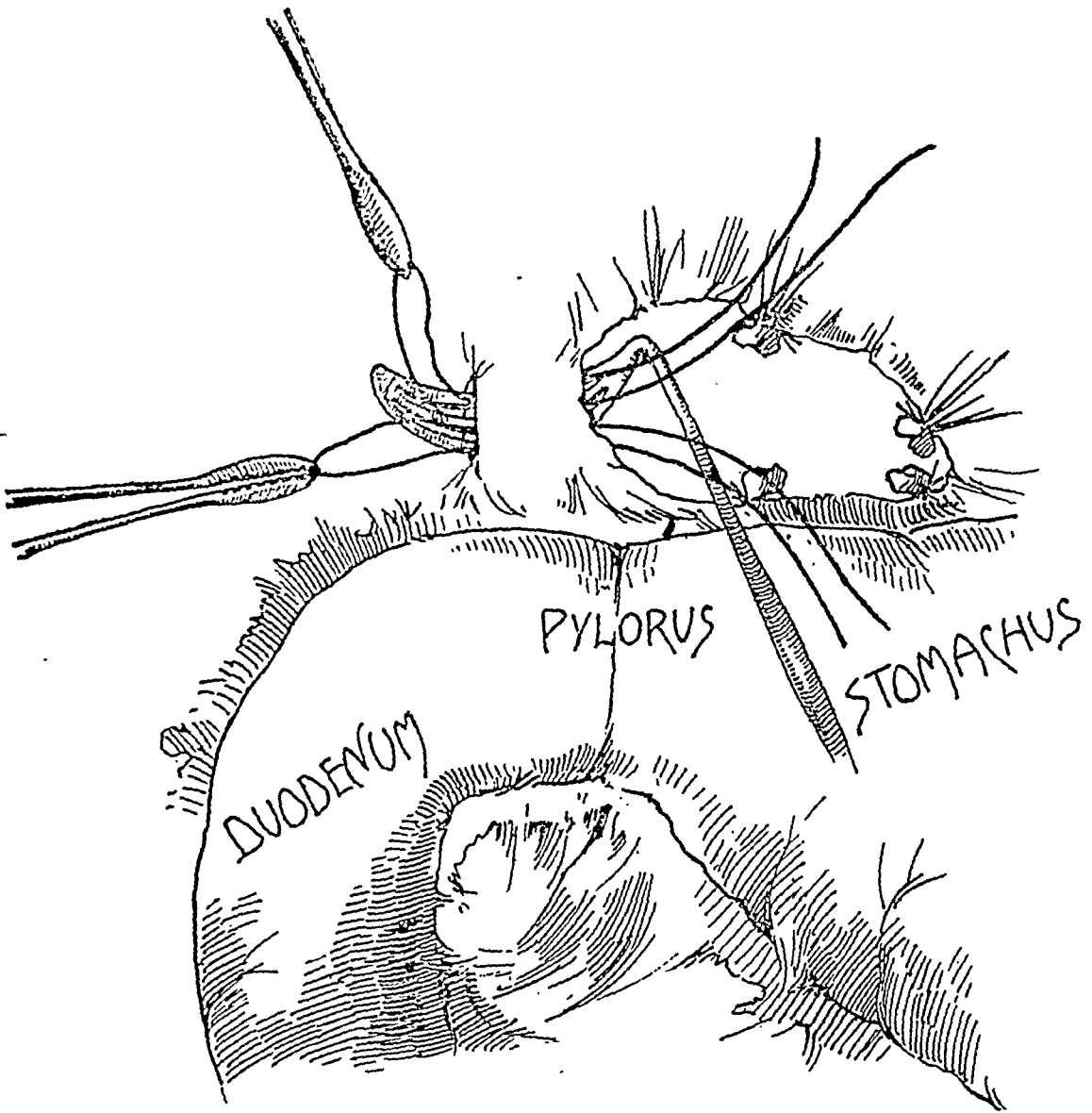


FIG. 4

tissues to be divided, the surgeon should take hold of either one of the threads with a forceps, the assistant taking hold of the other, and then pulling back the needle. In this way, there is no possibility of making a mistake by twisting the threads, and the ligation of any tissue that has to be divided between two ligatures is made easily and rapidly (Fig. 4).

We would suggest that the surgeon should use threads of different colors and qualities, as we always do, particularly in cases of resection of

the stomach. While dividing the mesos, linen thread is used on the portion that will be resected, and catgut is used on the ligatures that will remain in the abdomen.

With the double-eyed aneurism needle, ligatures and divisions of tissues are rendered more easy and rapid: they are much more rapid than when the single common-eyed aneurism needle is used, because the surgeon has not even the trouble of dividing the thread, which division at times causes trouble, because one end of the thread remains too short.

The double-eyed aneurism needle does not cause the surgeon to lose his temper, as is so often the case when, for instance, the threads get twisted.

Working with the aneurism needle mentioned above is rendered even more rapid and easy by threading each eye of the needle with threads of a different kind or of different colors.

BOOK REVIEWS

THE EARLY TREATMENT OF WAR WOUNDS. By Col. H. M. W. GRAY, Late Consultant Surgeon British Expeditionary Force, France. London. Oxford University Press, 1919. Octavo; cloth; pages, 299.

This little book is now chiefly of historical interest. At the time when it was compiled, in August, 1918, the most active phases of the International war were being wrought out and the demands for surgical effort under the peculiar conditions of military activities were incessant and important, and no one at that time was optimistic enough to indulge the thought that the collapse of the German power was so near at hand. The foreword by Lieutenant-General Goodwin, Director of the Army Medical Service, bears the date of September 9, 1918, and in his contribution to the book the General emphasizes the immense assistance which such a book should give to the Army Surgeon, evidently under the full impression that for an indefinite time yet the demand for the application of its teachings would still be called for. The morning of November 11 put an end at once to the extraordinary conditions which gave importance to such a book. We accept it now, however, as a clear and interesting record of the conditions and methods of the military surgery of that war. The book belongs to the same class as that of Hull on the Surgery of War which has recently been the subject of a review in the ANNALS.

The author aptly remarks in his preface that the late war was the young man's war in surgery as well as in purely military matters, since mental and bodily activity counted for much in the ability to meet the demands which the progress of events were continually making upon the endurance and the responsiveness of those who were to do its work. The demand was for young surgeons of fresh and active brains and dexterous hands.

The author says that it was a great privilege and honor to work with the medical officers of that army whose keenness and efficiency were inspiring and whose thoughtfulness and courtesy afforded constant encouragement. Alike with others who were familiar with the conditions of medical relief on that field of strife, he does not fail to give high honor to those assistants of humbler rank who contributed so large a share in bringing about the happy results which were secured. He says, "The stretcher-bearer on the field is one of the heroic figures of the war." None will gainsay the truth of his statement that medical officers who have not experienced the stress, anxiety and limitations of the work near the front during severe fighting can appreciate the problems and the necessities of the work which had to be done under such surroundings. Surgeons in advanced units, even in quiet times, only approach the ideal which it is possible to attain in more permanent surroundings. The particular method adopted by a medical officer at the front in any given case must be determined by the conditions on the spot, the facilities

at hand, the number of cases that come in, and the circumstances affecting evacuation.

It is in such a state of mental toleration and judgment that the general surgeon is to view the principles of work that must govern the surgery of such a war as this which has recently been waged. We cannot do better than to quote the paragraphs with which the author begins Chapter I.

"It is beyond the power of words to convey anything but the feeblest impression of the conditions under which surgical work is carried on at a very advanced unit during a big 'push.' For the doctor fresh from a palatial, well-ordered hospital, who has hitherto had all things made easy in virtue of his training and surroundings, and who may be so confident of obtaining good results that he dreams of performing marvelous operations at the front, there will be much to learn and much to unlearn. The dimly lighted dugout dressing-station, the dust, the wet, the mud, the blood, the noise, the bustle, the numbers of wounded, the appalling wounds, the hopeless shock, will open his eyes, test his capacity and resource, and tend to break his heart as never before. Here is no brilliantly lighted and fully equipped theatre, here his patients do not come before him in spotless apparel, here he has not unlimited skilled assistance, here no aseptic ritual is possible, here he must be content with very simple things. And through it all he must keep cool, he must hurry, he must be thorough, he must be gentle and careful in every possible way. His is the responsibility to make or mar a man for life. Often his patients shattered in nerve as well as in limb can give but feeble response to his utmost efforts so that a little slip in judgment, a little unnecessary exposure, a little lack of ordinary comfort even, or a little rough or unconsidered handling will tip the scale and send them to that death which their foes have desired.

"One is impressed by the fact that the methods of treatment which are most successful are those which are simplest and follow the indications of nature most closely. The medical officer who can land his patient at the next stage of the journey in best condition with the fewest contraptions serves his country best. Some measures described are so simple that, were they not so frequently neglected, it would appear almost superfluous to draw special attention to them. Principles of surgery remain the same, but the application of them is perforce adapted to local conditions. Original minds will always devise the means to the end in the greatly varying and new conditions which this war will continue to force upon them. At the field ambulance, at the casualty clearing station, at the hospital on the lines of communication in France, and at the base hospitals in England, the problems of surgery are widely different. Even the most skilful hospital surgeon of civil life must pass through an apprenticeship at any of these places before he becomes of the same value as his house surgeon of prewar days who has qualified in war surgery. The experience of even a few weeks may produce a wonderful revision of the standard of values.

"No work is done under such a variety of conditions as the work of

the field ambulance and of the regimental medical officer. The circumstances in which a field ambulance finds itself, and the resources at its disposal, are so different under the conditions of ordinary trench warfare and of a big engagement that it is impossible, as in the case of other units, to lay down hard and fast rules that are of more or less universal application. What is easily attained under ordinary conditions may be absolutely impossible during the heat of a battle, and methods of treatment that are well within the reach of ambulances working in one portion of the line, may be entirely impracticable to those working under less favorable conditions.

"The conditions of warfare demand that wounded men shall be got out of the way so that supplies of reinforcements, ammunition, and food to the fighting line are not interfered with. But while the primary function of advanced medical units is to clear the wounded as rapidly as possible, yet the enormous importance of preventive work must constantly be kept in mind. The effects of treatment of the wounded man at the earliest stages are reflected in the whole course of his subsequent illness. The influence of efficient early treatment cannot be overestimated. The fate of a life or limb is often determined before the arrival of the wounded man at the casualty clearing station, and no subsequent surgical skill can undo an error that has previously been committed. The 'results' of the casualty clearing station, to a great extent, reflect the good or the bad work of the forward units. Treatment begins when the patient is first seen, and not in the operating theatre. The prevention of early complications gives a man a good start in his struggle. Only the most necessary procedures can be carried out, but these must also be the best possible.

"*Shock*.—The intense surgical shock from which some of the wounded suffer must be seen in order to be appreciated. Primary shock from the injury is aggravated by unavoidable early handling and by transport of the patient. This fact is brought home in a negative way by the observation that a man with a fractured femur who lies out for a day or two after being wounded, arrives at the casualty clearing station in better condition on the whole as regards pure shock than one who is picked up and transported without delay. A comparatively smooth railway journey has a deleterious effect. How much worse is the effect of transport down uneven trenches, over rough country, and along bumpy roads! A wounded man left lying out keeps his limb at rest and recovers from the first shock of the injury. Close attention must be paid to these indications because other considerations compel the immediate removal of the patient to a place where he can be operated upon to the best advantage. Every effort must be made to prevent the summation of painful stimuli, which transport inevitably provides, from producing fresh shock or intensifying, beyond the patient's endurance, the shock already present. The most important elements in combating the development of profound secondary shock are rest, both mental and physical, and warmth. Rest during the journey is procured by proper fixation and efficient support of the injured part and prevention of jarring bumps. Com-

plete rest to the patient is out of the question at this stage and therefore the aid of sedatives has to be invoked, and should be used as early as possible in order to render him less sensitive.

"The great majority of the severely wounded give evidence of the existence of some degree of shock or collapse, and attention to their general condition is as important as attention to their wounds. Shock is generally due to the combined action of several causes, amongst which the most common are: (1) Hemorrhage; (2) exposure to cold, wet, hunger, and fatigue; (3) pain and anxiety; (4) the presence of multiple injuries; (5) the injury of some important organ, as in lesions of the trunk and head. Next to the actual injury, the journey from the trenches to the casualty clearing station is the most potent factor in producing shock, and every effort must be made to render his journey as easy as possible for the wounded man. This can only be done by attention to innumerable details, which, considered separately, may seem insignificant, but taken collectively may make the difference between life and death to the patient. Viewed in this light, no attention that contributes to the wounded man's comfort during his journey is so trifling as not to merit care and consideration. The good work of an ambulance rests on attention to these details rather than on the performance of surgical operations.

"There is no measure which is of such vital importance to a seriously wounded man as the provision of warmth. The first complaint heard in a regimental aid post is almost always of cold, and throughout the wearisome journey to the casualty clearing station the same complaint is repeatedly voiced. Many stretcher cases arrive at the clearing station so cold that the pain of their wounds has been relegated to the background, and in severely shocked cases the surface temperature may have sunk to as low as 90 degrees. During winter months the mortality from shock materially rises as the result of the increased cold.

"The chief protection of the wounded man against cold during the first part of his journey lies in the liberal use of blankets. At no time is the loss of heat more rapid than during the first two hours after wounding, and every effort must be made to prevent exposure to cold at this period. Nothing is more striking than the deterioration in condition that takes place when a stretcher case has been sent on his journey without a blanket beneath him as well as one on top.

"During bad weather wet clothing should be removed as early as possible and the wounded man put into a dry suit of pajamas. Sometimes this may be done at an advanced dressing station, but often no arrangements for the change into dry clothes are to be found further forward than the main dressing station. The advantages of an early change are enormous, and every effort must be made to accomplish it as far forward as possible. It is impossible to get a wounded man warm while he is surrounded by a cold compress of wet clothing, and to get a man warm is as important an item in ambulance treatment as to dress his wounds."

BOOK REVIEWS

The subject of the application of dressings, the stanching of hemorrhage, the treatment of fractures, the special cares called for in head wounds, chest and abdominal cases, are all briefly considered.

A special chapter is devoted to the work at the casualty clearing station. The work of the casualty clearing station, he remarks, should be judged from the condition in which its patients arrive at the base rather than by the number of cases which it passes through, although in times of highest pressure the latter function becomes of equal, if not of paramount importance. On some occasions, indeed, the casualty clearing station has to be transformed into a glorified dressing station. Operations, unless most urgent and at the same time most hopeful, are given up for the time being. At all times the aim must be the greatest good to the greatest number. In conclusion of this branch of his subject he says that the surgeon fresh from civil practice will speedily find that war wounds in France behave very differently from those to which he is accustomed at home, unless they are treated efficiently on certain definite principles. If these principles are appreciated, common sense and good technic in their application will insure a great measure of success.

After a chapter devoted to the treatment of wound shock and to a general consideration of the use of antiseptic dressings, the author arrives at a consideration of the principles that should guide the treatment of gunshot wounds. Of chief importance is the principle that a patient who requires operation should be operated upon as soon as possible!

A long time elapsed before the value of free incision combined with excision of lacerated tissue was appreciated and before it was realized that gas gangrene must be treated on the same lines as sarcoma. Free incision relieves tension and thereby improves the local circulation. Excision removes parts which have had their circulation definitely obstructed and will become or already are affected with gas gangrene. The presence of anaërobic gas-forming organisms is so widespread in the soil of France that all lacerated wounds must be regarded as being infected by them. It is necessary, therefore, to excise all lacerated, or obviously infected, muscle until freely bleeding tissue is reached.

The difficulties which surround the operating surgeon of the casualty clearing station in many cases are extremely trying. If operation is performed too early, the patient will die of shock; if unduly postponed, he is likely to succumb from acute sepsis. It is difficult for those who have not had experience at the front to appreciate that infection can develop so quickly as it sometimes does. Men have succumbed to acute gas infection within twelve hours of the reception of the wound; in a large number it is well advanced in twenty-four to forty-eight hours. Acute septicæmia is frequently present at the same time, and, when due to streptococci, it is particularly fatal.

A full consideration is given to the early excision and suture of gunshot wounds, the method which became fully established as the method of choice in the last years of the war.

Wounds of the brain and its coverings are given full consideration in one of the most important chapters of the book.

The chapter which perhaps will arrest attention most certainly is the rather brief Chapter 8 devoted to the penetrating wounds of the thorax. Early in the war it became appreciated that the mortality of chest cases was high and that with very few exceptions only those of the more trivial types of wounds lived to reach base hospitals. In the case of open wounds, unless immediate operation was performed, it was quite exceptional for patients to get to the base at all. They died in an advanced hospital or en route.

It was long, however, before the general body of surgeons recognized that if great loss of life was to be avoided, such cases must be treated on the principles which govern patients with wounds in other parts of the body. The result of such active treatment has been that now the best operators send out over 70 per cent. of their cases of penetrating gunshot wounds of the chest recovered to such a degree that they gave every prospect of becoming useful citizens and some of them even able to return to full military duty again. As in wounds of other parts of the body, no case can be pronounced free from the danger of sepsis. The liability to early fulminating sepsis depends chiefly on the size of the wounds, especially of the entrance wound. Sepsis has been the cause of early death in most of the "sucking wounds" which reach the casualty clearing station. Between cases with closed chest wounds and those with open, possibly sucking wounds, there exist a fairly large number in which decision as to treatment is fraught with great difficulty and anxiety. The possibility of giving relief to the patient and preventing a problematical development of sepsis must be weighed against the danger which the operation necessary for such a double purpose involves.

The mortality from sepsis developing after the patient has been forwarded to a base hospital has been so great as to constitute a decided indication for interference in a larger number of cases at the casualty clearing station. There is, however, a large number of cases, constituting from 25 to 30 per cent. of the entire number, in which the nature of their wounds is such as manifestly to demand operation at the earliest possible moment. Mere closure of the wound will in no measure prevent development of sepsis, a condition which in this class of case is usually extremely virulent and lethal. Therefore, thorough excision of lacerated tissue and removal of blood clot and foreign bodies are essential to ultimate success in the treatment of penetrating wounds of the thorax, as in the treatment of gunshot wounds of other parts of the body. The lessening mortality which has followed the more frequent adoption of early radical operative means has been sufficient to furnish complete justification for such radical operation in severe cases.

A brief chapter follows devoted to injuries of the spinal cord.

Compound fractures of the femur are given a special chapter.

Wounds of joints are fully considered. One notes that in this chapter the author does not omit to make mention of the practice of Willems and other Belgian surgeons in instituting active movements of a wounded joint,

BOOK REVIEWS

saying, that by their practice the hope has been aroused that even in suppurating joints, once the site of primary infection has been removed, a useful movable joint may be obtained. The theory on which their success is said to depend, that only by active movements can a joint be thoroughly drained, is so opposed to what surgeons have hitherto believed to be proper treatment that caution in adopting the method is excusable. But many old-fashioned notions have been upset during this war. One can remember well the incredulity with which the results of excision of wounds were received, and one cannot afford to neglect the brilliant results which have been demonstrated by the Belgians. It would appear necessary that if success is to attend such treatment, it must be initiated at a very early stage; it must not be instituted as a last resort, if it is to have a fair chance.

With this chapter upon wounds of the joints the book closes. It is good reading and may serve as an excellent epitome of the special elements of the Military Surgery of the recent war. It is free from wearisome statistics and is rather a discussion of principles with brief considerations of practical and technical details which at no time are permitted to be so numerous or minute as to embarrass the general progress of the more important plan of the work. We have quoted freely from many pages of this book, attracted by the importance of the considerations which it presents and, even more, by the attractive style and the literary value which these pages display.

LEWIS A. PILCHER.

CORRESPONDENCE

FREE TRANSPLANTATION OF TENDONS

EDITOR ANNALS OF SURGERY:

At the present time, when the surgical world is especially interested in problems of reconstruction, perhaps the details of an operation which was performed at the Samaritan Hospital three years ago would be of some interest, especially as it involved the use of a free tendon transplant. The literature of surgery is rather full of tendon transference and on the use of free transplantation of other tissues, but so far I have seen little mention of the use of tendons in the manner to be described.

A man fifty years of age presented himself at the orthopædic dispensary of the Samaritan Hospital with a disabled right hand, the result of a lacerating and crushing injury, followed by infection. The fourth and fifth fingers had been caught in a machine in a mill several months previous to the time that he presented himself to us. The resulting infection had necessitated the amputation of the fifth finger at the proximal joint. The flexor tendon of the stump had contracted to such a degree that the stump was in close apposition to the palm, and in that position was giving rise to great discomfort. The fourth finger had also contracted in a badly flexed posture, due to tendon contraction. It seemed that the joints of the fourth finger were unaffected, so far as we could determine clinically and by use of the X-ray.

It was therefore determined to amputate the stump of the fifth finger and to attempt a tenoplasty on the flexor tendons of the fourth. Under ether anæsthesia an incision was made on the palmar surface of the fourth finger from the distal joint to a point slightly below the metacarpo-phalangeal joint; the flexor sublimis was exposed and found to have been practically destroyed by the infection. The sheath of this tendon was also partially destroyed. The tendon and the sheath were freed and cut transversely, several other bands of adhesions being divided; the tendon of the flexor profundus was then exposed, and it was found to be in good condition; it was also divided transversely, as its size hardly permitted us to attempt the usual method of tendon lengthening. The finger could then be straightened, and it was found that the joints were freely movable; however, with the finger in the extended position there was a gap of an inch between the cut ends of the tendon. It was then decided to utilize the extensor tendon of the stump of the fifth finger for filling in this gap. Accordingly the tendon was exposed and a somewhat longer piece than was actually needed removed. The free transplant was then sutured in the gap of the flexor profundus, leaving a considerable overlap at either end. The sheath was closed with fine chromic gut, skin incision closed with no further regard to the flexor

CORRESPONDENCE

sublimis tendon, the finger was dressed in full extension. The stump of the fifth finger was then amputated in the usual manner:

No infection occurred in the wounds. Passive motion was started at the end of sixteen days, he being treated three times weekly in the massage clinic. Gradually voluntary flexion control of the fourth finger developed, until at the end of two months he had about one-half normal flexion. Then he disappeared, and all efforts to locate him have been unavailing. There is little reason to doubt, however, that he gained a functionally useful finger.

While conclusions drawn from one case have little value, it would seem that in a hand where there are a number of disabled fingers and it is found necessary that one or more be sacrificed, that the tendons of the useless fingers, provided such tendons are in good condition, could be utilized in the manner described.

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PHILADELPHIA, PA.

COMPLETE TORSION OF GREAT OMENTUM

EDITOR, ANNALS OF SURGERY:

IN looking over recent literature, I have been unable to find a report of the whole great omentum twisted at the transverse colon without apparent cause, therefore I consider the following case a rarity and of sufficient interest to warrant its report.

Mr. Snyder was admitted to the Seton Hospital April 15, 1919, having been referred by Doctor Riecker of Cherry Grove, Ohio, with a tentative diagnosis of acute appendicitis. Examination revealed a robust man of thirty-seven years. He gave a history of having had three attacks of cramps during the past year, which were relieved in twelve to twenty-four hours by taking castor oil. During the last year he had suffered from so-called indigestion and made it a habit of taking some form of cathartic every night.

The present onset began about twenty-four hours before his entrance into the hospital, when he experienced a severe pain about his umbilicus. His temperature, taken at the hospital, was 98, his pulse 60 and respirations 18. Examination of his abdomen revealed no distention and no signs except a slight rigidity of his right rectus muscle and tenderness over his right lower abdomen.

Because he was complaining of pain and because of the rigidity and tenderness, with the history of his previous attacks, we thought it best to operate at once, even though his temperature and pulse were normal.

He was taken to the operating room and a right rectus incision made as in operating for appendicitis. When the peritoneum was reached it could be seen that there was blood underneath, giving the appearance which frequently presents itself in a ruptured ectopic in the female. Upon

CORRESPONDENCE

opening the peritoneum dark blood immediately escaped from the peritoneal cavity and gangrenous omentum presented itself. The incision was immediately enlarged upward giving exposure of the entire abdominal cavity. It was then seen that the entire great omentum was gangrenous and twisted about five times at the transverse colon. The transverse colon was not twisted itself, but the omentum had torn itself loose from its splenic portion, thus accounting for the hemorrhage. The large and small bowel was apparently normal in every respect and the appendix was found normal. There was no hernia.

One point which struck me as significant was that the omentum had overlapped itself from left to right, that is, from the spleen towards the liver, so that its splenic attachment had been torn loose.

In trying to account for this condition I could find no basis other than his repeated catharsis, as he stated that he never missed a night without taking a physic. It seems far-fetched, indeed, to imagine that the antiperistaltic waves of the transverse colon could become increased to such an extent as to cause an overlapping of the great omentum, still this is the only explanation which I can offer. It is the only case which I have ever seen of this kind, and I have been unable to find any uncomplicated cases recorded in the literature. Hedley in the *Brit. Med. Journal* of November 11, 1911, studied records of 73 cases of torsion of the great omentum. In 60 cases there had been a hernia; in 5 cases there were adhesions without hernia. In a large portion of the cases the omentum was found in a sac.

My patient made a normal recovery after his omentum was removed.

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CINCINNATI, O.

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THE INFLUENCE OF THE WAR UPON THE DEVELOPMENT OF SURGERY *

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OF NEW YORK

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It has been my great privilege to work side by side with the surgeons and physicians of France throughout the period of the war, and I could ask for no greater honor than that you have accorded me in inviting me to speak to you to-day. This honor I accept, not wholly for myself, but also as a tribute to my fellow American surgeons.

I must confess to a feeling of disappointment in regard to the influence the experience derived from the observation and treatment of wounds during the war has had upon the development of surgical science. There has been little of new in the knowledge we have obtained. There has rather been a confirmation of principles already known, and the progress that has been achieved has been principally in stabilizing treatment rather than in making discoveries. I do not wish to imply that the page of progress has been blank. On the contrary, as we shall see later, there have been fruitful investigations and observations, chiefly in regard to some of the infections and to shock. There has, however, been no development to change the underlying principles of wound treatment as recognized and practiced before the war. This, in view of the enormous amount of material afforded by the war, might be deemed an admission of failure; but when we reflect that the processes of repair in all wounds, no matter what their cause, are essentially alike, and that these processes have been studied for years, there is little ground for disappointment.

It is extremely interesting to note that this very natural desire to improve upon the accepted methods of wound treatment exerted a profound psychological influence upon surgeons during the first years of the war. It was so great, in fact, as to lead them to discard acknowledged facts and embark on a wild empirical search for a universal panacea for wound infections. In this swing of the pendulum towards antiseptic treatment, not only were the younger and ignorant surgeons involved but also many older men who had passed through the old antiseptic era and should therefore have known better. It was only during the last two

* The LOUIS LIARD lecture, delivered at the Sorbonne, Paris, April 1, 1919.

years of the war that the aseptic principles of wound treatment became re-established, and it is to the credit of France that this was accomplished chiefly by her surgeons.

A brief review of the phases through which the treatment of wounds passed will be to the point.

At the outset of the war military surgeons assumed that the great majority of wounds would result from small arms, *i.e.*, rifle bullets, and that the casualties from high explosives such as shells, bombs and grenades, would be in the minority. It was also thought that rifle bullets would produce clean, neat perforations such as might be made by a large knitting needle. There was no conception of the fact that the full-jacketed bullet could so often cause bursting and shattering effects. Consequently the dictum was that there would be few operations and that only small dressings would be needed; with the result that inadequate provision was made. When the avalanche of wounded descended, with lesions of indescribable magnitude and laceration and mostly containing foreign and infectious material, a demand naturally arose from the overwhelmed surgeons for some means, capable of application by no matter what attendant, to combat the frightful infections which ensued. Thus recourse was had to antiseptics, and the antiseptic era was revived. Our old friends reappeared: phenol, Labarraque's solution, iodoform, the metallic salts and alkaloids, as well as the aromatics of the ancients. Perhaps I should not say *reappeared*, for they were always with us; rather they became dominant. And because they became dominant I feel justified in saying that the early surgery of the war was characterized by retrogression rather than by progression.

No one can deny that antiseptics are of value, but instead of being considered as the basis of treatment they should only be employed as aids and as supplements, and particularly when proper surgical technic is impossible.

Many years before the war it was often remarked that some of the older surgeons, when operating, achieved as good or better results than did the younger men, although the asepsis of the former was questionable, while that of the latter was impeccable. It was easy to find the reason. The older men, most of whom had been trained before the use of general anæsthetics had become prevalent, operated with speed, depended chiefly on the knife, and left clean-cut surfaces; the younger surgeons, often uncertain in their knowledge of anatomy, operated more laboriously, tearing and separating the tissues by blunt dissection and leaving wounds containing shreds of devitalized tissue. Although the older men had introduced many more bacteria, the wounds inflicted by them healed more kindly, very often, than those made by their juniors. In the one case the sound living tissue destroyed the bacteria; in the other the devitalized tissues formed a favorable medium upon which the occasional bacteria could multiply.

WAR AND THE DEVELOPMENT OF SURGERY

The principle that well-nourished tissues can withstand and overcome infection, while, on the other hand, tissues bruised and deprived of their circulation not only cannot destroy bacteria but become actual culture media favoring the development of infection, although perfectly well recognized and understood before the war, was often overlooked and forgotten.

War wounds, particularly those caused by artillery, possess all the conditions which promote infection: the structures are torn and disrupted, masses of tissue, even, may be detached, and, in addition, the projectiles frequently entrain clothing laden with germs.

The treatment of these wounds may be said to have passed through three stages during the war. The first stage was that of *débridement*: the wound was laid open, the foreign materials removed, and the tissues left to eliminate by natural processes those portions which could not live. In order to prevent and combat the fulminating infections resulting from the favorable conditions for bacterial growth, various antiseptics were used, some of which acted directly against the bacteria while others, by a sort of embalming process, rendered the destroyed tissues unfit for bacterial food. The evolution of the wound was characterized by prolonged elimination and suppuration.

The second stage of treatment was that in which substances, such as the hypochlorites, were used to dissolve the destroyed tissues and thereby hasten their elimination. Of these the most commonly used, at least in France, was Dakin's solution, which was applied throughout the wound by Carrel's admirable method of intermittent flushing. The essential value, as I have intimated, of the hypochlorites lies in their solvent properties, which, by getting rid of the pabulum for the bacteria, permit the tissues to sterilize themselves. This treatment finds its chief indication for those wounds to which the complete operative treatment about to be described cannot be applied.

The third stage might be said to have actually commenced early in the war, but it can hardly be stated to have become generalized before the spring of 1917. It might well be called the stage of rational treatment, for it was based upon the principles I have already mentioned, namely, that well-nourished tissues can not only withstand but can eliminate infection. Although this principle was well recognized before 1914 it remained to be proved that it was possible, operating under the unfavorable conditions of war surgery, to systematically convert wounds from hotbeds of infection into simple lesions healing immediately by first intention. It is particularly due to the excellent results obtained and reported by the French surgeons, and especially by Lemaitre, that this treatment became generalized. It consists, briefly, in paring (*épluchage*) the surfaces of the wound, removing all devitalized tissue and foreign materials, and closing it immediately, or, if for certain reasons, this did not seem practicable, leaving the closure to a later date. This rational treatment

has not only been extremely successful, but it has saved an enormous amount of time as well as of expensive dressing materials.

Although the principle of primary suture may not be new, yet rules were formulated for its application, which included organization of personnel and covered questions of transport, hospitalization, etc., and which should be of inestimable value in case of future wars, besides being applicable to a certain extent in civil surgery.

The study of the treatment of wounds is inseparably connected with that of the life history of the infecting organisms, that is to say, bacteriology.

Although the war has thrown practically no new light on the ordinary bacteria of suppuration, *viz.*, streptococci and staphylococci, much has been learned about the organisms producing gas gangrene. It is interesting to note that the treatment of this terrible disease in the early part of the war was also entirely directed against the infecting organisms, while later, it chiefly consisted in removing the conditions favorable to their growth. The bacteria producing gas gangrene all belong to the group known as anaërobes, because they thrive best in the absence of oxygen. A common treatment early in the war was to inject oxygen gas into and about the infected tissues; which did not do much more than increase the gaseous distention and thus produce more pressure upon the already anæmic tissues. Another treatment was to make multiple incisions in the subcutaneous tissues in order to let the gas escape. This might have done good if the gas had been formed in these tissues, but, as was subsequently proved, the gas there was innocuous. It was not until Kenneth Taylor, working in the Robert Walton Goelet Research Laboratory (then at the American Ambulance at Neuilly), proved that gas gangrene was essentially a disease of muscle tissue—not of healthy but of devitalized muscle—that the treatment was put on a rational basis. It then became simple: early excision of all torn and devitalized muscle prevented the development of the disease, and, when the symptoms had already appeared, removal in their entirety of the muscles involved usually stopped it.

Throughout the war attempts were made to treat this disease by anti-toxins and sera. Finally, but only during the past year, the French bacteriologists developed anti-sera which have apparently been remarkably successful. It is unfortunate that these discoveries were not made earlier, so that more time might have been available to establish their value; for gas gangrene is an extremely rare disease in civil life and there will be comparatively few opportunities for its clinical study. Yet, from the standpoint of pure science, the study of gas gangrene has unearthed an enormous amount of information in regard to the anaërobes and associated groups which cannot fail to have an influence upon the bacteriology of infection and therefore upon the surgery of the future.

With reference to tetanus, the prophylactic value of the antitoxin was proved, and its use became mandatory in the armies of all the nations instead of optional as had been the case in some. Until then, however,

hundreds of lives were lost because of this lack of appreciation of its value. A profound study of tetanus was carried on during the war, especially in the British army. It was found that the protection afforded by the antitoxin could not be depended upon to last more than from twelve to fourteen days. Thus the occurrence of what is called "late tetanus" was explained, and at the same time its prophylactic treatment was indicated. Studies of the bacterial flora of chronically suppurating wounds show that the tetanus bacillus persists for a long time, especially in and about the dead bone so commonly present in gun-shot fractures. The quiescent germs are apparently innocuous, the system of the individual being protected by the wall of granulation tissue lining the wound. If this living wall be broken down, however, whether by an operation or by rough handling of a fracture, absorption of toxin at once occurs, and, the protection of the original dose of antitoxin having ceased, tetanus ensues. The remedy is evident. Antitoxin must be readministered before any intervention which might destroy the natural barriers of the granulating wound.

The war has contributed greatly to our knowledge and understanding of the condition known as surgical shock. Shock is not only one of the chief causes of early mortality in battle casualties, but is frequently encountered in civil practice; and the importance of any contribution to our knowledge of its cause and treatment can hardly be overestimated. It would take too long to enumerate the theories which have been advanced in regard to the nature and causes of shock. It is sufficient to state that no clear definition of the condition or of its origin existed at the beginning of the war. True surgical shock as we now understand it, psychical shock and hemorrhage were confused with one another, and there were consequently conflicting views as to etiology and treatment. Shock is characterized by a progressive depression of the vital forces as evidenced by weakness of the systemic and cardiac muscles, lowering of bodily temperature, and, finally, death. Hemorrhage causes similar symptoms, and hastens the development of shock; yet pure surgical shock may exist without hemorrhage. It is largely through the investigations of Cannon during the war that a working hypothesis has been reached which affords a reasonable explanation of the phenomena attending shock and at the same time a basis for its rational treatment. Cannon's hypothesis is, briefly, that shock is due to a diminution in the normal alkalinity of the blood caused not only by deficient oxidation but also, more than probably, by the absorption of acid substances produced by the catalysis (*i.e.*, chemical breaking down) of injured muscle tissue. Anything which contributes to deficient oxidation, such as the loss of red corpuscles (hemorrhage) or the reduction of body heat, increases acidosis and, consequently, shock. And as shock produces cardiac weakness and lowering of blood-pressure (resulting in sluggish circulation and therefore in deficient oxidation), a vicious circle is quickly established and the

victim is doomed unless the chain can be broken. It has been found that if external heat be applied to the body, shock may be prevented or even arrested; but if the normal alkalinity of the blood has already undergone a certain diminution, fresh normal blood must be supplied by transfusion in order to restore the alkalinity and increase the blood-pressure and oxygen carriers. Infusions of alkaline solutions are not altogether satisfactory. By transfusion, the patient, having been temporarily resuscitated, is enabled to withstand the operation necessary to remove the crushed and torn muscle tissue, which, if allowed to remain, would again bring about the condition of shock and in any case lead to serious infection.

In order that the treatment of shock could be carried out efficiently, shock teams were organized. The personnel of these teams was generally recruited from the physicians and pathologists attached to the formation, so that the surgeons might be free for the operations. The duties of these teams were to classify the donors, prepare the blood, examine each patient on admission and, if in shock, see that the ordinary means of resuscitation were properly applied, observe the reaction of the patient to the treatment, and, if necessary, give a transfusion. The results obtained were excellent; the patients did not go to the operating room until they were ready to be operated upon, and therefore the operator's time was not lost in determining the condition of the patient and in giving transfusions.

The technic of blood transfusion was so perfected and simplified during the war as to make it far less dangerous, thus extending its use and therefore its value as a therapeutic procedure. One of the chief improvements, and one that might well be adopted for any civil hospital, was the classifying of donors among the personnel, so that blood suitable for any case could be immediately available without having to lose time in finding a donor with blood of the same type as that of the patient.

Much study was given to the effects of the different anæsthetics upon patients suffering from shock. Evidence was obtained by questionnaires sent to all the hospitals, and from discussions in the various meetings held in Paris and elsewhere. The consensus of opinion, which agreed with the laboratory findings, was that all the common general anæsthetics: ether, chloroform, ethyl chloride and nitrous oxide, were harmful, but that nitrous oxide with oxygen was by far the least dangerous. Although the harmfulness of general anæsthetics was admitted, their replacement by local or regional anæsthetics, except to a limited extent, was not considered practicable or justifiable, as the use of the latter is not devoid of danger. The superiority of nitrous oxide given with oxygen is undoubtedly due to the latter, for by its means the oxygen content of the blood is kept at a high point, thus obviating the danger arising from insufficient oxidation.

The result of these conclusions is that probably nitrous oxide with

oxygen will be employed in the future to the exclusion of other general anæsthetics except ether, which will be used as an adjuvant.

During the war considerable advances were made in the surgery of the regions, and particularly in that of the chest. Comparatively little progress was made in abdominal surgery. As regards the nervous system, there were certain improvements in technic and many observations of great value, especially as to the prognosis of certain injuries.

In the surgery of the jaws and face the large amount of material afforded an unprecedented opportunity for the artistic and imaginative surgeon; and some of them developed much skill and ingenuity in overcoming frightful deformities and in bridging dental defects. In this work there were not a few transplants and bone grafts, and future observations as to the permanency and the assumption of new function by these grafts will be of great scientific value.

The surgery of the chest has always possessed a charm for the adventurous surgeon, involving as it does that of the heart and lungs, the most obviously vital organs in the body. An operation on these moving structures will never fail to thrill the most indifferent and cold-blooded surgeon. Before the war the high mortality resulting from intervention for conditions which were then considered to be sufficiently serious to justify operative treatment, impressed surgeons with the idea that operations upon the chest were excessively dangerous. There were an enormous number of chest wounds of all descriptions during the war, with abundant opportunity to observe both their immediate effects and more remote ones, such as those produced by infection. One of the most striking observations was in regard to wounds opening the pleural cavity—the so-called sucking wounds. It was noticed that with such a wound a man got along fairly well for a short time and then rapidly went into shock and died. The reason was, as we have seen in the explanation of shock, a lack of oxidation due to inadequacy of respiration. If the admission of air through the wound were stopped, these cases did as well as those with non-sucking wounds. It became the rule, therefore, to close such wounds as soon as possible, even if they were only provisionally sewn together and had to be operated on and re-closed later. It was found that if shock could thus be prevented the patient could subsequently withstand a formal operation in the course of which the wound of the chest wall could be excised and enlarged, the lung withdrawn if necessary, the wounds in the latter also excised and sutured, and the chest finally closed. Closure of the chest, if only for a day or two to enable the vital functions to become readjusted, was found to be imperative. Naturally, under these conditions, it was of extreme importance that infection should be prevented, and it was therefore necessary to methodically remove foreign bodies, torn and devitalized tissue, and, more particularly, fragments of ribs, which were found frequently to provoke infection. It was seen that extensive exposure and handling of the lungs was possible, and our pre-

war ideas as to the dangers of thoracic surgery became greatly modified. Much was also learned in regard to the treatment of infections of the pleural cavities, including the empyemata caused by pneumonia as well as those due to wounds.

Of all war injuries, the most important without doubt, both from a humanitarian and from an economic standpoint, are those of the bony skeleton; in other words, the fractures, and particularly those of the limbs. Good treatment of fractures saves the use of limbs as well as lives, both for the individual and the nation; conversely, poor treatment cripples limbs and loses lives, and often makes the sufferers a charge upon society. Good treatment lessens by at least one-half or two-thirds the ordinary period of hospitalization, and when we consider that a large percentage of war injuries are fractures and that they require longer treatment than any other injury, the saving effected will be seen to be enormous.

Most surgeons in peace time are not particularly interested in fractures. In the first place, they do not occur in large numbers except in great factory or mining centres, and they do not as a rule appeal to the operating surgeon because they occupy beds for long periods and do not require the particular skill he possesses, or imagines he possesses, but a more purely mechanical one. At the outbreak of war, therefore, there was, generally speaking, a regrettable lack of knowledge as to the treatment of fractures. As a matter of fact, there was no authoritative work or report available on the treatment of war fractures, and what we know now may be fairly said to have been almost entirely acquired during the war. This would be unbelievable were it not for the fact that the war fracture differs greatly from the civil fracture in that it is caused by the direct action of a missile, while the civil fracture is usually the result of an indirect bending or torsional force. The war fracture is open to infection, the bone is smashed by the projectile, fragments of bone are often detached and driven through the tissues so that they actually form secondary missiles; foreign bodies, often loaded with infectious material, lie in or are disseminated amongst the fragments; the soft parts are lacerated, even pulpified; in short, the conditions are all favorable for the severest types of infection. Consequently the surgeon, in treating a war fracture, not only has to keep the fragments of bone in proper position but has also to contend with the worst forms of infection. In order that we may understand the difficulties he has to meet, let us consider what infection of a fracture means. In addition to the immediate danger to life from sepsis it causes death, or as it is called technically, necrosis of the fragments and ends of bone, the amount of necrosis usually depending upon the extent of interference with their blood supply produced by the injury. These dead pieces and ends prolong infection and hinder the processes of repair and union, and have to be removed by operation. If the operations for their removal are not properly timed or executed, more bone may die or other complications follow. There is always a tendency

on the part of the soft tissues to close too rapidly about the dead bone, confining suppuration and thereby causing abscesses to form which often burrow up or down the limb. In short, the clinical course of an infected war fracture is at first a severe infection immediately endangering life, and afterwards a sequence of flares of suppuration of greater or less danger. The gravity of these infectious processes can be greatly modified by skill and proper treatment.

At the outbreak of the war immobilization was the cardinal principle in the treatment.

In order that this should be perfect, the rules, as laid down in the textbooks, required that the articulations on each side of the fracture should also be immobilized. Treatment throughout the early part of the war was therefore consecrated to the principle of immobilization. The limbs, or, if necessary, the limbs and body, were encased in plaster of Paris, windows being cut or bridges of metal being made so as to afford access to the wounds for dressing purposes. What happened? In the first place, as infection developed swelling occurred, and the plaster casts had to be removed, split, or cut away. When this was not done soon enough, gangrene and loss of life were not uncommon results. When it was possible to keep the plaster casts on, wasting of the limbs from disuse made the casts too large, and they no longer fulfilled their purpose. Pressure was exerted in spots, causing sores; and filth accumulated beneath them. In some cases pneumonia developed on account of the fixation of the patient in a recumbent position. And if life and limb were preserved, what result was arrived at after this period of torture? In the best hands, as to union it was fair, although there was generally some shortening; as to function it was, almost without exception, lamentable, the joints were stiffened and the muscles wasted. In fractures of the thigh the results reported by some of the best clinics for the first year of the war show that less than two per cent. were fit to be returned to any kind of duty.

I am happy to state that this deplorable state of affairs no longer exists, and that, with the present methods of treatment, we may expect complete and comparatively early restoration of the use of fractured limbs in the majority of cases. Tissues and structures torn away or destroyed by infection cannot, of course, be replaced.

I do not think I am mistaken when I say that the improvement in treatment has been due to the discarding of the old precepts as to immobilization by fixation and the substitution of entirely different principles. I say *principles*, for the application of the treatment involves several mechanical principles, although the underlying physiological principle may be said to be that of the preservation of function.

The chief mechanical principle involved is that of traction. If traction be made on a broken limb in the direction of the axis of the proximal fragment of the broken bone when in the position of rest, no harmful angulation at the site of fracture will occur. By *position of rest* we mean

the position occupied when no forces are acting on the fragment other than those produced by the muscles attached to it. It has been found that very little external force (*i.e.*, acting from without) is sufficient to materially influence this position. Consequently, if a slight restraining external force be provided, considerable latitude of motion of the joint of which the fragment forms a part may take place without changing the position of the fragment. Now when traction is applied, the confining force provided by the stretched muscles is usually sufficient to furnish the slight external force necessary to prevent motion, and therefore traction in the proper direction may be expected to permit of considerable latitude of motion in the contiguous joints without changing the relative position of the fragments. This is found to be the case. Traction accomplishes more than this, for it also overcomes the tendency to overlapping and shortening. It has also been found that, with traction applied in the proper direction, the bending motion, *i.e.*, angulation, at the site of fracture which may occur in the early days of the injury, is harmless, and that the commencing union rapidly affords the slight restraining force necessary to maintain the relative positions of the fragments.

The problem then is how to maintain traction in the proper direction. It is obvious that if the direction of traction departs too far from that of the axis of the proximal fragment when in the position of rest, angulation will result at the fracture. We cannot overcome this danger by fixation unless it be complete and the joints on both sides of the fracture be immobilized; for, if we fix one side only, the danger is increased. On the other hand, if there be freedom of play on both sides, so that the parts on one side are able to follow any motion of those on the other, the danger is eliminated. This freedom of play is accomplished by suspension, and by removing the point from which traction is made to the farthest distance possible from the site of fracture. Moreover, the point at which traction is made should be, if possible, on the distal fragment itself, so that traction does not have to be made through the joints distal to the fracture, thereby immobilizing them.

The principles of treatment by traction and suspension are most readily applied to fractures of the humerus. It is interesting to note that the first cases treated by suspension and traction were three fractures of the humerus in my service at the American Ambulance at Neuilly in which there was enormous swelling of the forearm and hand. They were suspended in order to relieve the swelling, and it was supposed that some method of fixation would have to be applied when the swelling had disappeared. To our surprise, however, although the arms were swinging freely, union occurred very rapidly. This furnished food for reflection. Evidently immobilization was not indispensable. On the contrary, the nutrition of the limbs was infinitely better, and the motion of the joints was free. Last, but not least, the wounds were accessible and could be dressed without inflicting pain.

The method of applying traction and suspension to fractures of the

humerus has changed but little since that time; but it was found much more difficult to carry out this treatment in the case of the other fractures. Gradually, however, methods have been perfected, so that even in fractures of the femur not only is union without deformity obtained, but the motion of the joints is excellent when union occurs.

The most valuable feature of this treatment is the freedom of motion it affords, not only to the joints but also to the patient in bed. The vital functions are conserved, as well as those of the muscles and joints. We may therefore say that the chief underlying principle of the treatment is conservation of function.

We have learned much during the war in regard to the operative treatment of fractures. Although nothing new has been discovered we have gained great experience in determining the best treatment to follow. In the first place, internal fixation of compound fractures by screws, plates, bands or wires has been proved to be bad practice and unnecessary in view of the improvements I have already mentioned. The tendency at one time was towards the complete excision of all the small fragments in order to prevent infection and the continual suppuration which generally occurs when all the fragments are allowed to remain. Many instances of delayed union or total lack of union followed complete excision, and the present practice is a conservative resection of enough bone to remove contamination and to permit drainage, while at the same time maintaining continuity of the fragments.

The last stage I shall speak of in the treatment of fractures is actually the first, and is the splinting for transport from the battlefield. The inadequate methods employed in this work were one of the cruellest features of the early part of the war. It was not uncommon for wounded to be carried from the field with limbs swinging from the point of fracture, and the jagged fragments tearing and lacerating the tissues. The progress realized later was enormous, and here again was achieved by the use of traction, applied chiefly by means of the Thomas splint. This splint, used by the English orthopædist, Thomas, over fifty years ago, largely as an ambulatory splint for tuberculous affections of the knee, has, with slight modifications in size and form, been of inestimable service, both for transportation and treatment. In fact, with two sizes of this splint nearly all fractures of both upper and lower limbs may be transported and treated with success. It is simple and cheap as far as construction is concerned, but it requires considerable skill in handling. For transport, however, its application is governed by definite and simple rules. It was found, at least in the American army, that the enlisted men quickly became proficient in the application of this splint and were therefore able to splint the wounded where they fell. The latter were thus removed from the battlefield without suffering, and many were saved who would otherwise have died from additional traumatism and shock.

While the Thomas may be said to be the splint of the war, it was in use before the war and the war can only be credited with its generalization.

Perhaps the most efficient splint of all for transportation of fractures of the lower limb is that developed by the French surgeon Pouliquen. This is a happy combination of the Delorme gutter and the long Liston splints, to which attachments for maintaining traction are added. It occupies a very small space and is superior to the Thomas splint for the transportation of fractures of the hip-joint. This splint, I believe, should form a part of the equipment of every civil ambulance in preference to the Thomas.

The principle of conservation of function in the treatment of fractures is well exemplified in the Wilms treatment of wounds of joints. This treatment, introduced about the middle of the war by Doctor Wilms, of Brussels, aims at the retention of motion of the joints by never losing it. The wounded joint is operated upon as usual, the wound "épluchéd," and closed entirely or partially according to whether infection is absent or present. The after-treatment, which is the essential part of the system, is chiefly carried out by the patient himself, and consists in the use of the joint. He begins to move it immediately on regaining consciousness after the anæsthetic, and soon begins to use it. If a knee or ankle, he walks the day after operation. The results have astonished the surgical world. Joints which would have been doomed to ankylosis by the older methods have been perfectly preserved. Everyone who has employed the system agrees that it is marvellous. Some have complained that it lacks the miraculous power of achieving the impossible. This treatment, and the discovery that synovial membranes possess great self-protection against infection, are the two great advances in the surgery of the articulations due to the war.

Of the operations devised during the war, one of the most striking is the kinematic amputation of the Italian surgeon Vanghetti. The object of this operation is to arrange the stump so that the muscles may be used to directly activate the artificial limb, or, in other words, to vitalize the prosthesis. This is, indeed, a distinct advance, and bids fair, judging from the results already obtained, to be a very successful procedure.

So far I have reviewed what, it seems to me, are the chief additions to surgical knowledge and practice which may be credited to the war. In order to form a just opinion, however, as to its influence upon surgical science as a whole, we must place on the other side of the balance those developments which may exert a harmful influence in the future. Happily, these are chiefly habits or practices engendered by the stress and unavoidable cruelty of war, and which will disappear under the softening influence of peace. The courage and the spirit of personal sacrifice evoked are uplifting, but on the other hand there is much that is depressing and demoralizing, especially to the surgeon. Besides the long periods of enforced idleness, there is always the eternal conflict with the insuperable conditions imposed by war. The ordinary soldier is impressed by the dirt and everlasting discomfort; the surgeon is more than likely to be overwhelmed and his *morale* shattered. Overcome by the difficulties with

which he is surrounded, the impossibility of surgical cleanliness, the masses of wounded, he becomes indifferent and callous; he no longer strives for the ideal. If, in addition, he sees his results ruined and his patients lost through official stupidity, this attitude of mind is more than likely to be confirmed. In reality, it requires exceptional strength of character to come through such experiences without deterioration.

As I look back it seems to me that the most reprehensible specific practices resorted to during the war were the guillotine amputation and the general tendency to sacrifice skin. The guillotine amputation is, as its name implies, a chopping off, without the formation of flaps. It always necessitates a secondary amputation, with an additional loss of from 10 to 15 cm. of limb. It was supposed to be exceedingly efficacious for gas gangrene, and actually proved to be so when done above the highest point reached by the disease. When we consider, however, that the extension of gas gangrene is usually confined to a single muscle or group of muscles and can therefore be eradicated by excising these muscles and leaving the others, the fallacy of the argument is exposed. Yet questions of this kind are so difficult of proof that it is possible the guillotine amputation will remain with us for years to come.

The final stage in the influence of the war upon the development of medicine and surgery, lies chiefly in our own hands and depends upon the perpetuation of the cordial and fruitful relations which have existed during the war between the physicians and surgeons of the different armies. It will indeed be regrettable if the stimulus to progress engendered by the meetings of the Interallied Surgical Conference and the Research Committee of the American Red Cross should be permitted to subside. Now is the time to act, while the memory of the events through which we have passed is fresh in our minds and the friendships formed are still warm.

Military organization will have to be supplanted by some other. Shall we look to the national and international societies and congresses, or shall we turn to our great universities? It seems to me that the latter offer the best means for fostering and perpetuating the spirit of enthusiastic coöperation brought about by the war, for they afford opportunities for continuous collaboration and interchanges of ideas. On the other hand, international meetings should be encouraged, not only because of their purely scientific value, but in order to revivify the cordial personal relations which have been such a redeeming feature of the war.

For myself, if I felt that my approaching return to America would be the end of all this, I could not go. I am sure I am voicing the desire of many of my American *confrères* in hoping that in the near future we may have the honor and great pleasure of receiving our European brothers in America in order to be able to make some return for the kind hospitality, the thoughtful helpfulness, and sympathetic appreciation we have always received over here.

FRACTURE OF THE FEMUR *

A CRITICAL ANALYSIS OF 131 CASES OF FRACTURE OF THE FEMUR, TREATED AT THE
AMERICAN RED CROSS HOSPITAL, NO. 2, PARIS

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It is the object of this paper to analyze statistically 131 consecutive cases of fracture of the femur treated in the American Red Cross Military Hospital No. 2 at Paris. A brief outline of the principles and methods of treatment will also be given, but for the details of the mechanical treatment by traction and suspension the reader is referred elsewhere.¹ The report includes all fractured femurs admitted to the hospital from the time of its opening in April, 1917, to the time of its closure in February, 1919. Of these fractures, 18 occurred in French soldiers and the remainder in members of the American Expeditionary Forces.

The material has, in a way, been selected. We have included in the series only those cases of fracture of the femur in which the weight-bearing femoral stem has suffered a complete loss in continuity. Thus, we have excluded cases of wound of the shaft of the femur without fracture, and cases in which there has been a wound of a trochanter or condyle without loss of continuity of the femoral stem as a whole. Wounds of the knee- and hip-joints in which the articular femoral surface has been the only portion of the femur involved have also been excluded. No cases amputated before admission are herein reported, and no cases of complete union which have passed through our hands merely in transit.

The series should, in many ways, give statistical material of value. It comprises early and late cases, and cases operated upon by many different surgeons, both French and American. Its cases have been operated upon in many different hospitals. It includes cases operated upon only a few hours after injury at field hospitals, and unoperated cases received in Paris during the days of stress in June and July, 1918, four and five days after injury; cases with their primary field dressing still in place—or no dressing at all—and cases with thighs twice their natural size as the result of advanced gas gangrene. It includes cases transported early and late after operation; cases transported with well-applied Thomas splints, cases splinted with German rifles, and cases not splinted

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¹ Blake, Arch. de méd. et phar. mil., Par., 1916, lxvi, 289; Blake and Bulkley, La Presse Médicale, No. 64, Nov. 19, 1917; Blake and Bulkley, Surg., Gyn. and Obstet., 1918, xvi, 245.

FRACTURE OF THE FEMUR

at all. The report is thus a composite one, as the hospital functioned for a time as a base hospital situated far behind the lines, and for a time as an evacuation hospital well within the advance area.

The cases were received as follows:

	AFTER INJURY				
	1st week	2nd week	3rd week	4th week	Later
Compound unoperated cases	50	2	0	0	0
Compound previously operated cases	34	4	9	7	16
Simple fractures	6	2	0	0	1
	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>
	90	8	9	7	17

The great majority were thus received in less than a week following injury, and considerably over half of these came to us still untreated save for a field dressing and a transportation splint. As practically every case has been under the personal supervision of the writer, uniform observation has been possible.

In a way the series is not representative of the American army. Almost all the cases came from one locality, namely, the triangular area of northern France included between the cities of Chateau-Thierry, Soissons, and Rheims, and the immediately adjacent country. A series of cases drawn from a larger sector of the Western Front would give a far more true picture of the prevalence of infection, for it has been repeatedly shown by various writers that the soil differs markedly in virulence in different localities. And the series is not truly representative of fractures of the femur as they have occurred throughout the war, inasmuch as there are an unusually large percentage of cases wounded by bullets and a correspondingly small number of high explosive fractures. This is explained by the fact that during the period during which the majority of these fractures occurred, the fighting was almost all of the "open" variety, with a constantly changing front line and no prolonged trench warfare. But it is hoped that an analytical study of them may throw some light on the high mortality rate and relatively poor end result of this injury, probably the most serious economic one of the war.

ETIOLOGY

All of these men were injured in the pursuit of war. Sixty-five were injured by bullets, either rifle or machine gun, all sustaining compound fractures. As will be developed later, *some* of these cases healed by primary union without operation, thus falling shortly after injury into the category of simple fractures. Forty-eight were wounded by shell fragments. All of these were compound fractures and remained so. In 8 cases the type of missile was undetermined. All were compound fractures.

There was but 1 injury by shrapnel ball. There were 9 simple fractures; 5 by motor vehicle accident, 3 by falls from a height, and 1 by the blow of an aeroplane propeller. There were no fractures by hand grenades. The relative amount of injury caused by the different types of missile and the relation of these latter to infection will be considered under Pathology.

PATHOLOGY

Side Involved.—The right femur was fractured in 68 cases, the left in 59 cases; there was 1 fracture of both femora, and in 2 cases the data are lacking.

Site of Fracture.—The neck of the femur was involved in 8 cases (6.1 per cent.), the upper third of the shaft in 24 cases (18.2 per cent.), the middle third in 56 cases (42.7 per cent.), and the lower third in 41 cases (30.9 per cent.). In 2 cases of double fracture, the upper and lower thirds were both involved, leaving isolated central fragments.

Joint Involvement.—In all 7 cases of compound fracture of the neck of the femur (one case was a simple fracture), the hip-joint was involved and every case suppurated irrespective of the type of treatment used. In 12 of the 41 cases of fracture of the lower third, the knee-joint was involved by splitting or communication into the joint cavity. Irrespective of the level of the femoral fracture, an effusion into the knee-joint may occur. It is usually serous but may be bloody. It is a true, rather transitory, traumatic arthritis, the trauma being transmitted from the site of impact of foreign body along the shaft of the bone to the joint. In fractures of the lower third of the femur it is often difficult to decide whether the joint effusion is due to a traumatic arthritis thus transmitted or due to a splitting directly into the joint cavity. We have seen a number of cases in which the radiograph failed until the fourth or fifth picture to demonstrate the fissure, due to the fact that plates were made only in an antero-posterior and lateral plane. In cases of this nature in which there is a doubt, it is advisable to take oblique plates.

Type of Fracture.—In the majority of these cases the fracture was comminuted, often extensively, with fragments of bone buried at some distance from the site of fracture in the surrounding muscles. Vertical splitting was common, frequently resulting in the separation from the shaft of the bone of a large wedge-shaped fragment involving the entire thickness of the cortex. From one or the other end of such a fragment the continuity of the periosteum with that of the shaft was usually preserved, a point of importance in the operative treatment of these cases. The amount of comminution did not seem to depend to any great degree on the type of missile. Machine-gun and rifle bullets frequently caused as extensive a comminution as did shell fragments of similar size. Missiles of low velocity, usually remaining *in situ*, and particularly those striking the femur just below the trochanters, caused more comminution than those moving at a greater speed and striking other portions of the

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bone. As far as could be determined, in all but 3 cases of this series the fracture took place only at the point of impact of the missile. In these 3 cases fracture apparently occurred by *contre coup*. In one of these a shell fragment about 1 cm. in diameter struck the femur just below the trochanters, fracturing it at that point and also at a point 5 inches below. The fragment was in this case retained. In a second case a bullet, after traversing the knee-joint without bony injury, entered the opposite thigh, drilled cleanly through the shaft of the femur without fracturing it at the point of impact, and caused an oblique fracture of the shaft at a point 4 inches above the site of bone wound (Fig. 1). This bullet was undoubtedly travelling at an extremely high velocity. The wound of the knee-joint and that of the thigh both healed by first intention without operation, resulting in a hæmarthrosis which quickly disappeared with aspiration and a fracture of the femur which clinically could be considered for purposes of treatment as a simple fracture. In a third case a machine-gun bullet struck the upper third of the femur, fracturing it at that point and remaining *in situ*. There was also a second fracture 4 inches below this point.

Associated Injuries.—These may be divided into those directly connected with the fracture and those situated in some other portion of the body. In every compound fracture there is by definition an associated injury of the soft parts. The muscles are invariably injured, the degree of damage being in direct proportion to the cross section of the impacting surface of the missile and to the amount of comminution of bone. It depends also to a considerable degree on the perfection of immobilization during transportation. The muscle is frequently injured at a considerable distance from the site of fracture by bony fragments driven into it at the moment of impact of missile and femur. Thus we have seen a localized gas gangrene of the sartorius, a muscle which at no point touches the femur, due to the burying in it of a fragment of bone. This muscle had at no point been injured by a missile. Other than muscle injury, we have observed relatively few injuries of the thigh associated with fracture of the femur. There was one case of division of the sciatic nerve. The larger muscular branches of the anterior crural nerve were frequently found divided, but no accurate records of these findings were kept. There were no cases of division of the main femoral artery, although frequent examples of the division of the various larger muscular branches were encountered. There was one case of division of the superior perforating branch of the profunda femoris which caused at operation an annoying hemorrhage difficult to control. The posterior tibial artery was divided in one case by a missile passing in an oblique direction and causing also a fracture of the tibia. Of the injuries of the soft parts of the thigh associated with fracture of the femur, we consider that of the muscles to be most important because of the possibility of ensuing gas gangrene.

Of the 119 compound cases of this series, 28 or 23.5 per cent., had associated injuries other than those of the thigh. The following table briefly indicates their character:

Comp. fract. tibial head (one case having in addition a fract. of the tibia and a divided posterior tibial artery)	2
Comp. fract. tibial shaft	1
Comp. fract. patella	1
Comp. fract. humerus with divided musculospiral nerve	1
Comp. fract. radius with multiple gun-shot wounds of soft parts	2
Comp. fract. radius and ulna	1
Comp. fract. hand phalanges	3
Comp. fract. bones of elbow-joint necessitating resection of elbow	1
Comp. fract. carpal bones with through-and-through wound of elbow-joint	1
Gun-shot wound of knee-joint without bony injury	2
Division of sciatic nerve and comp. fract. metatarsals	1
Division of urethra	1
Multiple gun-shot wounds of soft parts, some of them severe	11

The femoral lesion was thus in the majority of the cases of the series the most serious injury received.

Infection.—Attention has been repeatedly called to the fact that the American army is particularly susceptible to infection, especially with the streptococcus. No attempt will be here made to discuss this susceptibility other than to take cognizance of the fact, as considerable discrepancy will probably be noted between our figures and those of our British and French colleagues working with their own troops. We regret that our data on these cases are not more complete, especially that the results of the cultures made from the wounds on admission are not all available. In the main only two types of organisms have been searched for, streptococci and one of the gas-producing pathogenic anaërobes. In all cases where the streptococcus has been found, its hæmolytic or non-hæmolytic capability has been determined. In the cases of the anaërobes their presence or absence only has been noted. Our ideal has been to take a culture from every wound on admission and at weekly intervals thereafter, occasionally more often, but in the rush of work this ideal was far from realized. Accordingly the bacteriological portion of the report must be considered as far from complete.

Gas Gangrene.—Twenty-seven cases of this series, or about 23 per cent. of the compound fractures, on admission or shortly after admission showed *clinical* evidence of gas gangrene, in some of the cases far advanced. In one case there was no gangrene of the involved thigh, but marked gangrene was present in the calf of the same leg, due to the passage of a second missile. In a second case there was a gas gangrene of the opposite thigh. Some had been operated upon previous to admission, some had not. In some the infection was not noted for a number of days following admis-

FRACTURE OF THE FEMUR

sion. The clinical diagnosis was made by the usual train of symptoms: increased pulse rate in relation to temperature; abnormal pain; increased size of the limb; copper discoloration; distended cutaneous venules (of particular value in cases of deep gas infection in which the main muscular sheaths have not as yet ruptured, and possibly explained by the interference with the deep return venous flow); subcutaneous or intramuscular crepitus; change in percussion note of the limb; exploratory aspiration; and at operation by the appearance of the subcutaneous tissue and muscles themselves. The infection frequently involved an isolated muscle or group of muscles, at times extending practically from origin to insertion. In cases of advanced and widespread gangrene it was common to find the sheath of the femoral vessels or of the sciatic nerve acting as a path along which the gas spread. The fascial sheath of the involved muscle was invariably tense, so that on incision the underlying muscle protruded. The areolar tissue surrounding a muscle group was oedematous. Subcutaneous gas on the anterior abdominal wall was not an infrequent finding.

It is of interest to note the time after injury at which these cases of gas gangrene came under observation, and the type of missile which caused the injury. Of the 27 cases, 12 had been previously operated upon. They were admitted to our service on the following number of days after injury: second day, 1 case; third day, 3 cases; fourth day, 1 case; fifth day, 3 cases; sixth day, 1 case; seventh day, 1 case; eighth day, 2 cases. We amputated 6 of these cases immediately on admission because of their general condition, the advanced state of their gangrene, and the severity of the bone injury. Of the remaining 6 cases all were also immediately re-operated, extensive débridements being done. Of these, 1 was never amputated, dying on the twelfth day. Autopsy showed no cause of death other than a progressive gas gangrene. The other 5 cases were amputated on the seventh, ninth, ninth, tenth, and eleventh days, respectively. (For death rate of these cases, see later under Mortality.)

Of the 15 cases admitted with gas gangrene and not previously operated, all were immediately operated upon. They were admitted as follows: first day, 2 cases; second day, 9 cases; third day, 2 cases; fourth day, 2 cases. Four were immediately amputated. The remaining 9 were immediately débrided. Of these, 3 were subsequently amputated. Thus 18 of 27 cases of fracture of the femur with associated *clinical* gas gangrene were sooner or later amputated. As we will show in discussing the treatment, more should have been amputated primarily.

Of the 27 cases, 12 were wounded by shell, 10 by bullet, and in 5 cases the type of missile was undetermined. Referring back to our total number wounded by the two types of missile, we find that 15 per cent. of the fractured femurs caused by machine-gun or rifle fire developed clinical gas gangrene as against 25 per cent. of those wounded by shell fragments. This is probably accounted for by the relative amount of clothing carried

into the wound, the clothing in the majority of instances rather than the missile itself being responsible for the ensuing infection.

It has been our practice to depend more on the clinical evidence of anaërobic infection than on the laboratory findings from wound cultures. However, it may be of interest to note briefly such bacteriological data as we have at hand on this subject. There are positive bacteriological anaërobic findings in 14 cases which clinically at no time during their course showed gas. In some of the cases of this series wound cultures showed the presence of anaërobic bacilli up to as late as 100 days after injury. In every instance this finding was in a case of long slow sequestration with retained fragments. The finding is not an unusual one, but is cited simply to emphasize the fact that anaërobic cultural findings do not necessarily imply the presence of an active clinical anaërobic infection. In one case the bacillus *aërogenes capsulatus* was isolated from a piece of cloth removed from the wound sixty-seven days after injury.

Before leaving the subject of gas infection, we wish to call attention to a particular type of injury which almost invariably results in an anaërobic infection. We refer to the cases in which a missile passes transversely through the upper portion of a thigh, then through the perineum or just below it, and enters or passes through the opposite thigh. There were 5 injuries of this type in this series, all developing gas gangrene. In one case the thigh first struck was fractured. In the other 4 cases the fracture occurred in the second thigh. In all 5 cases the second thigh struck developed gas whereas the first thigh remained clean. Although we have not the figures before us, we are strongly of the impression that among similar wounds of the soft parts without fracture which came under our observation, the same phenomenon was frequently observed. This observation does not hold true for wounds 6 inches or more below the perineum.

Streptococcus Infection.—It is rather more difficult to give definite figures in relation to the incidence of streptococcic infection among this group of cases, but it has been all too frequent. It has been responsible for some of the early deaths and, with the exception of a lobar pneumonia, for all the late deaths, either directly or indirectly. It has been responsible for the large majority of complications. In 25 of these cases blood culture records are available. There was one positive pneumococcus finding, the case having a lobar pneumonia and recovering. There were 8 cases with positive streptococcus blood culture which died. There was one case with a positive culture which recovered. There were 11 cases suspected of harboring the organism in the blood stream whose cultures all remained sterile. All these recovered. There were 4 cases of chronic sepsis with multiple streptococcus abscesses which died, but from which positive cultures before death could never be obtained. In one of these the streptococcus was obtained at autopsy from the heart's blood. The streptococcus in every instance belonged to the hæmolytic group.

FRACTURE OF THE FEMUR

There are wound cultures available from 76 cases. In 43 of these cases the streptococcus was at some time found, in 12 cases being associated with the bacillus *aërogenes capsulatus*. In the remaining 32 cases the cultures proved negative. Referring again back to the total number wounded by the two types of missile, we find that 30 per cent. of the cases wounded by bullet developed streptococcus wounds, and 43 per cent. of the cases wounded by shell. It is an open question as to whether a certain number of these cases of streptococcus wound infection are not "hospital" or "ward" infections. Unfortunately, our data are not sufficiently complete to settle this point, as the proportion of cases in which a culture was obtained and recorded from the admission to the discharge of the case is not sufficiently large for study.

There were 2 cases of latent infection, both fatal, which seem worthy of particular note. Both were wounded by machine-gun bullets and both died as the result of streptococcus infection. The first case was received twenty-four hours after injury, having been wounded by a bullet which had entered and lodged in the right thigh, causing an oblique fracture of the mid-third of the femur. There was no indication for operative interference and except for the mechanical treatment of the fracture the patient was not disturbed for twenty-eight days. His temperature, which previous to that time had been normal without fluctuation, then became irregular, and on the thirty-seventh day after injury an abscess about the site of fracture was opened and the bullet removed. No clothing was found. A pure culture of hæmolytic streptococcus was obtained from this abscess. The patient developed a streptococcus sepsis with positive blood culture and died on the fifty-eighth day. At autopsy there was no union and a multiple suppurative streptococcus arthritis was found.

The second case was also received twenty-four hours after injury, a machine-gun bullet having passed through the left thigh, causing an oblique fracture of the mid-third of the femur. There was no indication for operative interference, the temperature remained normal for eight days and the small points of entry and exit apparently healed by first intention. On the eighth day the temperature began to become irregular, but nothing definite could be found until the seventeenth day, when an abscess was found and opened at the site of fracture. This yielded a pure streptococcus. Blood culture and culture from wound were repeatedly negative. The leg became a mass of dissecting pus pockets and finally on the fortieth day a disarticulation at the hip was done. In the meantime the patient had developed a multiple suppurative arthritis. He died shortly after operation from shock and sepsis. At autopsy a pure culture of hæmolytic streptococcus was obtained from the heart's blood.

Tetanus.—No other infection of any moment was encountered in this series other than tetanus. As will be brought out under Mortality, the late deaths were almost all due to streptococœmia, the terminal event

being a bronchopneumonia, a septic embolus, or visceral degeneration from sepsis. There were 3 cases of tetanus, 2 fatal, 1 recovering.

The first (Case 53) died on the seventeenth day following a resection of the head and neck of the femur for a compound comminuted fracture of the neck caused by shell. This case was complicated by the presence of a gas gangrene at the time of the first operation, seventeen and one-half hours after injury. He received 1500 units of antitoxin at the time of injury, but as far as can be determined no further antitoxin until the time of onset of symptoms of tetanus, two days before death. At autopsy no cause of death other than tetanus was found.

The second case (Case 104) was received four days after injury, having been primarily operated upon at a field hospital twenty-four hours after injury. He was not reoperated after admission, was treated mechanically for his fracture, and ran a normal temperature for forty-six days. His temperature then rose and symptoms of tetanus appeared. On the forty-second day his wound showed a culture of *bacillus aërogenes capsulatus* and on the sixty-fifth day he showed a positive streptococcus blood culture. On the sixty-sixth day he died, still with a trismus and spasms of the injured leg despite enormous doses of antitoxin. No operative procedure was done. He should have been amputated at the first symptoms of tetanus. At autopsy a multiple suppurative arthritis and a terminal bronchopneumonia were found.

The third case (Case 122) was that of a major admitted one hundred and thirty-six days after having received a compound fracture of the lower third of the femur by shell. He was transferred to our service, a distance of over 100 kilometres by ambulance, and on the day following admission showed a definite trismus and twitching of the injured leg. He had primarily been operated on at a field hospital on the day of injury. As far as could be ascertained, no further operative procedure had been carried out. On admission position was extremely poor. There was no union and terminal exposed sequestræ were evident in an open wound. He was given 100,000 units of antitoxin during the first three days, and then an average of about 10,000 units a day for ten days. On the one hundred and fortieth day a sequestrectomy was done. By the one hundred and fiftieth day symptoms of tetanus had disappeared. On the one hundred and sixty-sixth day because of toxæmia and anatomical loss through suppuration he was amputated and went on to complete recovery. Tetanus was in this case activated by ill-advised transportation.

Complications.—Other than those already described as the result of infection, the complications were relatively few. There were very few cases of decubital gangrene, and with the exception of one case all occurred in late cases of sepsis. Despite the number of streptococcus infections, there were no cases of true erysipelas. There were 2 cases of lobar pneumonia (1.7 per cent.), one recovering and the other (a negro) quickly succumbing. All other cases were of the bronchopneumonic type

FRACTURE OF THE FEMUR

and occurred during the terminal stages of a streptococcus sepsis. There was one severe secondary hemorrhage from an unamputated leg with gas infection. One amputated case required religation on the twentieth day. One case developed diphtheria on the thirteenth day.

TREATMENT

The primary operative work done on these cases is unquestionably the most important part of their treatment, for thereon depends frequently not only life and the conservation of the limb, but also its ultimate function. On the operative treatment first carried out also depends not only the early anaërobic and severe streptococcus infection, but also the late chronic infection so frequently seen in the form of osteomyelitis and long slow sequestration. This work should not only be done at the earliest moment after injury, but should be carried out by the best surgeons a country can send to its fighting men. The later treatment of these cases can be left to the care of less experienced men working under proper guidance.

To decide whether in a given case of fracture of the femur the case is non-operative or operative, and, if the latter, what the type of operative procedure shall be, is, in the opinion of the writer, as difficult a problem as exists in the realm of surgery. Previous to the statistical study of this series of cases and possibly stimulated by certain adverse criticism, we had felt that perhaps we had been too radical in our treatment. Now that the analysis has been made and the group studied in retrospect, we are convinced that our main error in treatment lay on the side of conservatism. We feel at least that our mortality rate would have been considerably lower if we had not so steadily persevered in our effort to conserve limbs.

We will first summarize briefly the operative treatment to which these cases were subjected, apologizing for a certain admixture of autopsy findings which we feel we must quote at this time for purposes of clarity. We will study the cases in groups, first taking up the injuries caused by the two main types of missile and then considering the injuries according to the location of the fracture.

BULLET FRACTURES

As before noted, there were 65 cases of fracture by bullets. Of these, 16 were kept under observation without operation. Of the 16, 12 healed by primary union (18 per cent.) and remained clean. Two cases developed abscesses which were opened on the twenty-fourth and sixty-third days, respectively. Both went on to complete recovery without further operative treatment. The two other cases developed abscesses on their seventeenth and thirty-seventh days, respectively, and both died of a general hæmolytic streptococæmia, the organisms being recovered from

the blood stream before death in one case and at autopsy from the heart's blood in the other. Both of these cases should have been amputated, as one (Case 47) did not die until the fifty-eighth day, and the other (Case 40) not until the fortieth, although the fatal outcome was entirely unexpected at the time when amputation would have been of value.

Nine cases were operated upon at the first opportunity, either by us or at a field or evacuation hospital. A double conical débridement was the usual procedure. Intact or nearly intact missiles were removed, lead "splatterings," such as shown in Fig. 2, were not usually sought. All of these cases recovered without further operation.

Eleven cases were similarly operated and differed from the 9 just mentioned only in the fact that late sequestrectomies were necessary.

One unoperated case was admitted on the third day with advanced gas gangrene. An immediate sausage amputation was done. This patient died on the nineteenth day with a positive hæmolytic streptococcus blood culture. At autopsy no sign of an active anaërobic infection was found.

Five cases were operated upon immediately on admission, were re-operated within a few days without amputation for spreading infection, and recovered.

Three cases were operated upon immediately and shortly thereafter were amputated for spreading infection. All recovered.

As against these last 8 cases, we wish to especially call attention to 9 cases which were operated upon at the first opportunity, *none of them being immediately amputated and all dying*, from what in retrospect we now consider to have been poor surgical judgment due to conservatism. These cases are sufficiently instructive to detail them briefly.

CASE 16.—This man was admitted thirty-six hours after injury, not previously operated, with an extensively comminuted femur and a marked gas gangrene. His wound was twice débrided. *He was never amputated.* Death on twelfth day. *Autopsy showed no cause of death other than an extensive gas gangrene of the thigh.*

CASE 21.—Almost identical with Case 16. Was three times operated but *never amputated.* At autopsy no definite findings other than a *progressive gas gangrene of the thigh.*

CASE 23.—First débrided in our service two days after injury. Rather chronically septic during entire stay in hospital. On fifty-fifth day an extensive sequestrectomy was done, followed by death six days later. Autopsy showed an acute rapidly spreading gas gangrene of the thigh. This was suspected the day after sequestrectomy, yet this patient was allowed to go on to death without amputation.

CASE 25.—Became septic on fifteenth day. *Never amputated,* although death did not take place until the forty-eighth day.

CASE 41.—Not amputated until eighteenth day. Autopsy showed *only a progressive gangrene of the stump.*

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SYNOPSIS OF 131 CASES OF GUNSHOT

	Admitted	Side involved	Situation	Etiology	First operation	Second operation	Third operation	Fourth operation	Amputation	Resection	Disarticulation	Gas	Ice tongs, tong traction		Reason	Reason	Removed	Steinman pin action
													Inserted	Removed				
1	4	R	U	Auto	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	5	R	M	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	L	L	B	1	10	18	43	1	1	1	1	37	65	Union	1	1	1
4	16	L	L	S	1	39	1	1	39	1	1	1	1	1	1	1	1	1
5	21	L	M	B	1	34	1	1	1	1	1	1	1	1	1	1	1	1
6	5	R	L	S	1	66	1	1	1	1	1	1	1	1	1	1	1	1
7	46	R	L	S	2	66	1	1	1	1	1	1	1	1	1	1	1	1
8	46	L	L	S	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	R	M	B	1	26	1	1	1	1	1	1	1	1	1	1	1	1
10	5	R	L	S	2	8	9	1	9	1	1	Yes	1	1	1	1	1	1
11	3	L	L	B	2	3	24	67	1	1	1	1	1	1	1	12	48	Union
12	5	L	L	B	1	5	20	1	5	1	1	Yes	1	1	1	1	1	1
13	46	L	L	S	1	57	1	1	57	1	1	1	1	1	1	1	1	1
14	46	L	N	B	1	25	1	1	1	25	1	1	1	1	1	1	1	1
15	3	L	N	B	1	18	25	53	53	18	1	1	1	1	1	1	1	1
16	3	R	M	S	1	3	1	1	1	1	1	1	1	1	1	3	48	Union
17	3	L	L	B	1	3	1	1	1	1	1	1	1	1	1	3	54	Union
18	4	L	U	S	1	4	1	1	4	1	1	Yes	1	1	1	1	1	1
19	7	R	U	S	1	7	1	1	7	1	7	Yes	1	1	1	1	1	1
20	3	L	U	B	3	16	18	1	18	1	1	1	3	18	Amputated	1	1	1
21	1	R	M	B	1	1	1	1	1	1	1	1	4	51	Union	1	1	1
22	2	R	M	S	4	1	1	1	1	1	1	1	2	4	See remarks	1	1	1
23	4	L	M	S	4	1	1	1	1	1	1	1	4	15	Death	1	1	1
24	49	R	M	Fall	1	52	1	1	1	1	1	1	52	77	See remarks	1	1	1
25	2	L	L	B	2	1	1	1	1	1	1	1	1	1	1	2	55	Union
26	5	L	M	S	1	10	20	64	1	1	1	1	1	1	1	1	1	1
27	7	L	M	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	8	L	M	B	1	63	1	1	1	1	1	1	1	1	1	1	1	1
29	2	R	U	B	5	1	1	1	5	30	1	Yes	2	5	Amputated	1	1	1
30	18	L	L	B	1	90	1	1	1	1	1	1	1	1	1	1	1	1
31	9	L	U	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	3	L	L	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1
33	8	R	L	B	1	8	9	1	9	1	1	Yes	1	1	1	8	9	Am
34	8	L	M	B	1	63	1	1	1	1	1	1	1	1	1	1	1	1
35	4	L	M	B	1	1	1	1	1	1	1	1	4	48	Union	1	1	1
36	8	L	M	B	1	1	1	1	1	1	1	1	8	28	See remarks	1	1	1
37	63	R	M	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1
38	16	L	U	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1
39	41	L	L	S	1	68	1	1	1	1	1	1	1	1	1	1	1	1
40	136	R	L	S	1	140	166	1	166	1	1	1	1	1	1	1	1	1
41	37	R	M	B	1	1	1	1	1	1	1	1	41	49	Slight infection	1	1	1

NOTES.—All figures refer to number of days after injury. Under bacteriology, "H.S." refers to the changed serially as far as possible under the date of admission to Hospital. Under "Situation," "N" refers only

FRACTURE OF THE FEMUR

CASE 71.—This patient on his twentieth day became septic, but was not amputated until the eightieth day, far too late. He died of an avoidable streptococcaemia.

CASE 80.—A fracture of the head and neck of the femur débrided only at an advance hospital. Also insufficiently cared for by us. He was admitted to our service on the fifteenth day, yet no resection was done until the fifty-fourth day and the patient was *never amputated*. He died of sepsis on the ninety-fourth day, having been septic for two months.

CASE 105.—Another fracture of the head and neck of the femur insufficiently operated "up the line," nineteen hours after injury, a simple drainage to the site of fracture and the hip-joint having been done. This patient was septic almost from the time of admission to our service, but was not resected until the eighteenth day. Wound constantly showed a hæmolytic streptococcus. After resection he remained septic with a positive hæmolytic streptococcus blood culture on the twenty-sixth day. He was not amputated through the hip-joint until the fifty-third day, far too late, with the inevitable result of almost immediate death. This man, as we will attempt to show later, should have been primarily amputated.

CASE 110.—A negro with an extensively comminuted upper third fracture not admitted until three days after injury, the fracture on admission badly infected. Should have been amputated immediately for anatomical reasons if for no other. Became septic and was not amputated until eighteenth day. Died shortly after operation from shock.

SHELL FRACTURES

We will briefly summarize in a similar way the cases wounded by shell. There are 48 such cases. All were operated upon.

In one case for some inexplicable reason a shell fragment was removed, no extensive débridement was done, the wound was closed without drainage and healed primarily. Unfortunately the data on this case are incomplete. We are inclined to believe that the fracture was caused by air concussion and that the shell fragment lay superficially. We do not in any way sanction this form of treatment.

In 10 cases the patient was operated upon at the first opportunity, no further operation was necessary, and recovery followed. Fifteen other cases differed from these 10 only in the fact that one or more late sequestrectomies were necessary.

Five cases were amputated immediately on admission, all for a complicating gas gangrene. Of these, 4 recovered and 1 died. The death occurred during a period of extreme activity in a patient who had been operated at an advance hospital twenty-four hours after injury and had apparently been untouched from that time until admission to our service, seven days later. On admission he was already practically moribund, with a late stage of gas gangrene extending from the umbilicus to the foot. He died almost immediately after operation.

Five cases were operated immediately on admission, were later amputated, and recovered. All of these cases might better have been primarily amputated, as, with the exception of one case, all required amputation rather shortly after their first operation.

One case, a negro, died on his fifteenth day from a lobar pneumonia involving the right middle and lower lobes. The condition of the leg was satisfactory at the time of death.

We will once again itemize the deaths which we consider should have been avoidable. All of them can be laid at the door of conservatism.

CASE 14.—Admitted thirty-six hours after injury with gas thigh. Débrided only. Similarly operated two days later. Not amputated until sixth day when nearly moribund. Autopsy showed *nothing but an extensive gas gangrene of the stump*.

CASE 34.—Operation on day of injury at an advance hospital. Admitted on eighth day with evident gas. Débrided only. Not amputated until eleventh day. Died on sixteenth day. Autopsy showed *nothing but a gas gangrene localized to the stump*.

CASE 36.—Previously operated. Reoperated twice but not amputated until seventieth day, although sepsis had been severe for weeks with a marked acetonuria and constant vomiting. Autopsy showed the usual findings of a hæmolytic streptococcus bacteriæmia. Amputation was suggested many times in this patient but always deferred because of temporary improvement. He could have been easily saved.

CASE 38.—No previous operation. Admitted on second day with gas. Débrided only. Reoperated on third day. *Never amputated*. Died on fifth day. Autopsy showed an extensive gas gangrene *limited to the thigh*.

CASE 50.—Admitted with gas and débrided forty-eight hours after injury. Did well for eight days. Then sudden spreading of gas gangrene. Was not amputated and died on following (eleventh) day.

CASE 53.—A fracture of the neck of the femur admitted eighteen hours after injury with gas. Débrided only. Resected on eighth day. Should have been amputated (see discussion of these cases later). Died on seventeenth day of tetanus.

CASE 76.—Operated upon at advance hospital on day of injury. Admitted four days after injury. *Never reoperated*. Developed tetanus on forty-sixth day and died on sixty-sixth. Should have been amputated at first symptom of tetanus as there was no union and suppuration was profuse.

CASE 88.—Another fracture of the neck of the femur, not resected until the thirtieth day and not amputated until thirty-fifth day. Died on forty-first day. Should have been amputated primarily. (See discussion later.)

CASE 94.—A low fracture with splitting into the knee-joint with profuse suppuration which also involved the joint. Was not amputated until thirty-ninth day and died on the seventy-seventh. Should have been amputated early.

FRACTURE OF THE FEMUR

CASE 100.—Admitted on ninth day, having been previously operated on second day. Knee-joint had been penetrated and sutured tight. Immediately opened and streptococcus pus obtained. Not amputated until ninth day, when an unsuspected gas gangrene limited to the vastus internus and spreading up the sciatic sheath was found. Died on eighteenth day. Amputation delayed too long. Gas should have been recognized.

As before noted, the primary operative decision in cases of compound fracture of the femur is difficult. In this series the error has undoubtedly lain on the side of conservatism. Débridements were not sufficiently extensive nor were a sufficient number of primary amputations done. We have just called attention to 19 cases, every one of which should have been more radically treated and the majority of which could have probably been saved. Eliminating the 12 cases of bullet fractures which healed by primary union without operation and remained clean, the incidence of infection, both aërobic and anaërobic, has been about the same in fractures caused by the two types of missile. The primary operative treatment should therefore in the main be similar. Incisions should be sufficiently large to allow complete exposure and dissection of the missile tract. They should be made, when possible, in the long axis of the limb. In the case of perforating wounds it is often wise to make the incisions on either side of the limb, the dissections being then deepened to meet each other in the form of a double conical débridement. All involved tissue, especially muscle tissue, should be carefully dissected and removed. Clothing is particularly dangerous and should be carefully sought for. Personally we prefer a knife to scissors for this work, as we feel that cleaner and more exact dissection can be done. Lead splatterings, as before mentioned, are usually not sought, as experience has shown that they are apt to be innocuous. Larger bullet fragments are removed and shell fragments invariably unless of extremely small size. Loose completely separated fragments of bone buried in muscle are felt for and removed. Otherwise bone is removed only if grossly soiled and to a sufficient degree to insure free drainage of the marrow cavity. It is well to remove such fragments posteriorly rather than laterally, if possible, in order to provide dependent cavity drainage. This bone removal must be done with great care, if due regard is to be had for the resulting union. It has been our practice to remove all such fragments subperiosteally, using for this purpose the set of cutting periosteal elevators devised by Ollier. Important structures, such as nerves and blood-vessels, should be dissected free and if possible preserved. Muscle anaërobically infected must be removed if the infection has progressed beyond the stage of œdema, and this removal must continue until muscle of normal color and appearance is encountered, muscle which bleeds readily when cut and reacts quickly to mechanical stimulation. At times this removal seems

brutal and unjustified, as, for instance, when the entire rectus femoris, sartorius, or one or more of the hamstrings is dissected from origin to insertion. But it is a procedure which must be carried out in order to obviate the necessity of amputation or be forced to face the alternative, death. Muscles showing œdema only will frequently recover with simple multiple ribboning of the sheath.

In certain cases, because of the obliquity and situation of the fracture, mechanical fixation of the fragments has seemed wise. In this series, mechanical fixation was used in 5 open cases. In 3 cases wire loop suspension of each fragment with the application of plaster of Paris was used by a French surgeon previous to admission to our service. In 2 cases we removed the wire on the fortieth and sixty-sixth days, respectively. In the third case a very wide resection had been done—apparently not subperiosteally, as there was no sign of new bone at the end of fifty-seven days—and the case was amputated by us on the fifty-eighth day. In two fresh cases we threw circular bronze wire about long oblique fractures at the primary operation as a temporary measure, removing the wire on the sixty-seventh day in one case. In the other case, because of sepsis, amputation was necessary on the thirty-fifth day. With improved methods in mechanical suspension and traction for these cases, we feel that direct mechanical fixation of bony fragments is rarely justified in gun-shot cases.

FRACTURES INVOLVING THE HIP-JOINT

The problem involved in these cases is somewhat different from fractures involving the shaft alone and merits a brief consideration. In our experience all gun-shot fractures, not only of the head but also of the neck of the femur, even of its base, involve the hip-joint. Let us first briefly detail and analyze the 7 cases which occurred in this series. They are discouraging.

CASE 32.—A fracture through the base of the neck by shrapnel ball. Débridement of the soft parts and drainage of the hip-joint forty hours after injury. Resection of the head and neck on the twenty-first day. Evacuated to the south of France on one hundred and twelfth day. Sinus still open. Patient still bed-ridden. No union.

CASE 53.—A fracture of the middle of the neck by shell. Gas present on admission. Débrided seventeen hours after injury with removal of loose bone fragments. Profuse suppuration. Resection of head and neck on eighth day. Developed tetanus and died on seventeenth day.

CASE 77.—A fracture of the base of the neck by machine-gun bullet. Débridement twenty hours after injury. Frequent incisions for abscesses up to forty-third day when resection of head and neck

FRACTURE OF THE FEMUR

was done. Developed a dissecting hour-glass abscess which travelled behind the femoral vessels and pocketed extraperitoneally in the false pelvis. After repeated operations for secondary drainage, he was evacuated to the south of France on his one hundred and eightieth day, with sinus still open, practically no union at the hip, and still bed-ridden.

CASE 88.—A fracture of the base of the neck by shell. Débrided twenty-four hours after injury. Resection of head and neck on thirtieth day. Became septic. Amputated through hip on thirty-fifth day and died of sepsis on forty-first day.

CASE 94.—A fracture of the base and shaft of the neck by sniper's rifle ball. Débridement twenty-four hours after injury. Resection of head and neck on fifty-fourth day. This patient ran a stormy and unhappy course, with repeated operations for secondary pockets, until death occurred on the ninety-fourth day from chronic sepsis and exhaustion.

CASE 104.—A fracture of the head and neck of the femur by machine-gun bullet. Débrided on first day. Resection of head and neck on twenty-fifth day. Ran a long course and was finally evacuated to the south of France on the two hundred and twenty-fifth day, still bed-ridden, sinuses still open.

CASE 105.—A fracture of the base of the neck by machine-gun bullet. Débrided nineteen hours after injury. Resection of head and neck on eighteenth day. Septic. Amputation through hip on fifty-third day. Almost immediate death from shock.

We feel that the treatment of every one of these cases was faulty. Their death rate was over 57 per cent. as against a death rate of 19.8 per cent. for the entire series. The cases which "recovered" were pitiful in their far from end result. Their period of hospitalization and convalescence was destined to include a very appreciable amount of the years allotted for life, and during this period they promised to be very constant sufferers. While we had no immediate operative mortality in the series, the operation of resection of the hip-joint is not an easy one. If done by the posterior incision, the external rotators are divided to such an extent that it is practically impossible to prevent the amputated end of the femur from riding up on the iliac flare. If done through the anterior incision, posterior stab-wound drainage which will not stay open must be provided, and constant pocketing occurs. How much easier it would be for both patient and operator to perform an immediate amputation through the site of fracture, waiting for ten days to remove the head and neck. With this the mortality rate should fall to about zero and months, if not years, of convalescence would be saved, with an end result which personally we would far prefer to those we have seen in late adult hip resections months and years after operation.

FRACTURES INVOLVING THE KNEE-JOINT

The fractures of the lower third of the femur which involve the knee-joint are also deserving of a brief word. We will omit the discussion of those cases in which the knee-joint of the involved side is penetrated by a second missile, or of those cases of penetrating or perforating wound of the knee in which there is an associated fracture of an articular surface or of a condyle only of the femur. We speak particularly of those fractures of the lower third of the femoral shaft in which there is a direct splitting into the joint. Attention has already been called to the fact that this fissure may be very small and of such a sinuous course that it may at first be easily overlooked in the course of a routine X-ray examination. But even so, it serves as a potential course for the direct extension of infection from the main site of fracture to the cavity of the knee-joint. Of 41 cases of fracture of the lower third of the femur, such a splitting occurred or was recognized 12 times. Seven were treated, as far as the knee-joint was concerned, expectantly. One healed cleanly without infection, an unoperated bullet case. Six suppurated. Of these, 5 eventually resulted in amputation. In the sixth case the joint recovered with drainage. Of the remaining 5 cases, 2 were treated by the aspiration of a clean hæmarthrosis and recovered without infection. One was amputated immediately on admission for extensive anatomical loss and division of the posterior tibial artery; 1 was amputated immediately for an extensive gas gangrene; and the other primarily resected and later amputated for infection. Thus of 12 cases of fracture of the lower third of the femur with splitting into the knee-joint, 8 sooner or later required amputation. This result is not good, yet we hardly know what suggestions to make to improve the prognosis of this injury. We feel most pessimistic regarding wounds of the knee-joint associated with bony injury. In our experience with a considerable number of cases not included in this series of wounds of the knee-joint associated with bone injury, either resection or amputation has eventually been necessary.

AMPUTATIONS

No discussion of the treatment of compound fracture of the femur can be complete without reference to amputation. In this series we amputated sooner or later 30 cases, about 23 per cent. of the compound fractures. The percentage is high, but as we shall presently show, should have been higher. The cases were amputated for the following reasons: For gas gangrene, 16; for severe secondary hemorrhage, 2; for anatomical loss, 2; for sepsis, 9; for osteomyelitis, 1. Practically all the gas gangrenes were neglected unoperated cases. Many were far advanced. In many the bony injury was extensive. The 2 cases amputated for anatomical loss had both been previously resected. Both might have better been pri-

FRACTURE OF THE FEMUR

marily amputated, as the initial loss was over 4 inches. The cases of sepsis varied from patients with legs which were masses of dissecting pus pockets to patients with suppurative knee-joints or generalized streptococcus sepsis. The patient with osteomyelitis was amputated for that alone. In both cases of severe secondary hemorrhage, gas gangrene was present.

The mortality rate of the cases amputated before the fourteenth day before they became chronically septic was 33 per cent. The mortality rate of those cases amputated later was 50 per cent. The rate for the entire 30 cases of amputation was 40 per cent. The earlier the amputation the lower the mortality rate. After a certain period of prolonged sepsis amputation is not well tolerated.

These cases are all sick. Amputation should be rapid. Team work is essential. Our practice has been to make a long anterior and short posterior flap, amputating by transfixion. The amputation may be done through the site of fracture, the large vessels secured, and then with the aid of the Percy saucer retractor the bone can be divided above the level of fissures. This has appealed to us as the quickest and best method, for if the patient does not react well, the division of bone can be postponed until proper reaction has set in some days later. If possible, however, it is better to divide the femur above the line of fissures at the primary amputation, as by so doing much infected material is removed. If the patient is still in good condition, all muscles (in gas gangrene cases) are then dissected upward and removed until healthy tissue is reached. The sciatic is drawn well out of its sheath and divided with a sharp knife. We have watched particularly for shock during this procedure and have failed to observe it. Consequently we no longer locally anæsthetize the nerve before division. The main vessels are doubly ligated with No. 2 plain gut. We have had no cases of secondary hemorrhage following this procedure. The wound is left practically unsutured, but the anterior flap is never under any circumstances turned back and sutured to the skin of the anterior thigh. We believe that sufficient gravity drainage is obtained if this flap is allowed to fall over the stump and that the exposure of the stump with the flap sutured back is distinctly disadvantageous.

For the control of hemorrhage during amputation we use a rubber tourniquet. The Esmarch bandage is prohibited because of infection. In high amputations because of the danger of the slipping of a tourniquet, we depend on manual pressure on the femoral vessels just above Poupart's ligament by a non-sterile assistant.

Most of the high amputations just below the anterior intertrochanteric line later need disarticulation because of the distressing constant flexion, abduction, and external rotation. It is not a difficult operation or one attended by shock. It should be done by an external incision about ten days to two weeks after amputation before too much cicatrization has occurred.

"CLEAN" OPERATIVE TREATMENT

In 3 cases of the series—I simple fracture by motor-cycle accident and 2 compound fractures by machine-gun bullets—operation was undertaken solely for the mechanical reduction and fixation of the fragments.

The first case (Case 30, motor-cycle) was admitted within two hours after injury with a transverse fracture of the mid-femur. Within three hours after injury a Lane plate had been inserted. Recovery was perfect and uneventful. It was interesting how easy it was to reduce and hold this fracture for plating. It could almost be done without assistance. This patient was treated by suspension and only 5 pounds traction for "steading" purposes, and motion at the knee was encouraged from the beginning. He was never immobilized and was evacuated walking on his seventy-seventh day with a practically perfectly functioning knee. The lack of plaster immobilization seemed to cause no tendency for loosening of the screws. He was seen following evacuation for a period of a number of months, on a duty status, having no further trouble. His plate was never removed.

The second case (Case 112) was that of a negro admitted two days after injury with a transverse fracture of the femur caused by the passage of a machine-gun bullet. There was no indication for operative interference, the leg was clean, and ice-tong femoral traction was immediately applied. Bed-side radiographs (Figs. 3 and 4) after thirty-six hours of heavy traction showed no overriding but displacement in both planes equal to the width of the femoral shaft, a finding pathognomonic of muscle interposition. Accordingly on his fourth day the tongs were removed, open reduction was done, interposed muscle was released, and the fracture Lane-plated. This patient was also suspended, no plaster was used, and convalescence was normal. The reduction is shown in Fig. 5. He was evacuated on the ninety-ninth day.

The third case (Case 42) was admitted two days after injury, having received an irregular fracture of the lower third of the femur by rifle-ball of such a form that the lower end of the femoral shaft was displaced from a triangular bed between the condyles to the inner side of the inner condyle. There was no infection and the patient was not operated. Glued traction after attempted manipulative closed reduction was first tried without success. On the eighth day tong traction was applied. As after five days of powerful traction it was found impossible to reduce and hold this fracture, an open operative reduction was done on the thirteenth day with some difficulty, the tongs being left *in situ*. To maintain the fragments in place it was necessary to secure them by one chromic suture placed through drill holes. In this case a perfect anatomical and functional result was obtained. He was evacuated on the seventy-fifth day, union having been noted on the forty-eighth. Unfortunately the plates on this patient are not available.



FIG. 1.—Bullet hole just shows at lower edge of picture.



FIG. 2.—Showing spattering of missile fragments through the tissues.



FIG. 4.—Lateral view after tongs were applied and before plating.



FIG. 3.—Anterior-posterior view after tongs were applied and before plating.

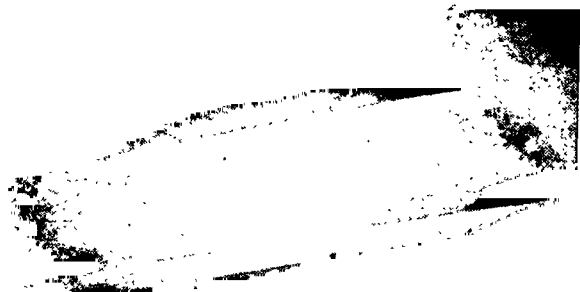


FIG. 5.—After plating. Plate can be indistinctly seen.

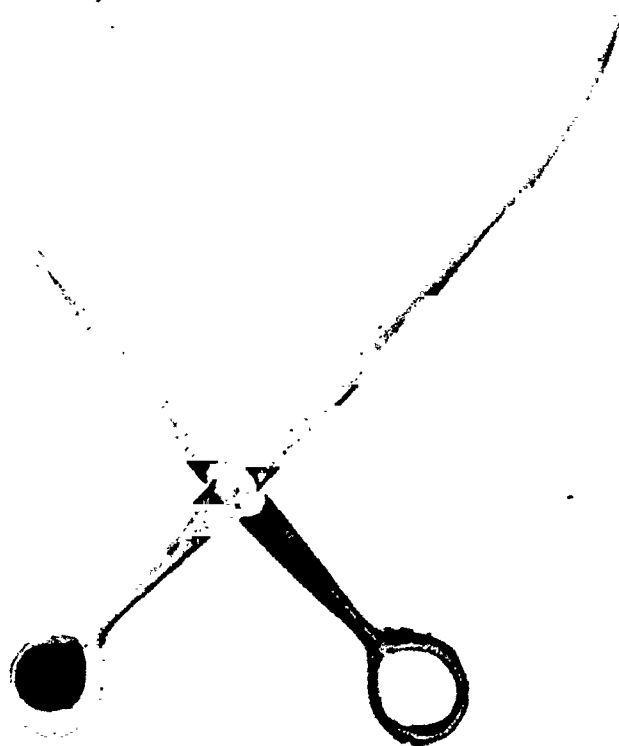
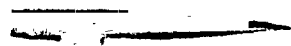
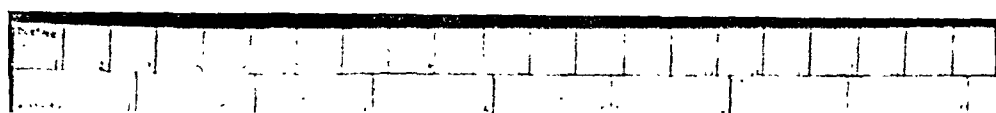


FIG. 6.—Traction tongs.

FRACTURE OF THE FEMUR

TRACTION

In 57 cases skeletal traction was employed at some time during the period of treatment. In the remainder of the cases traction was made by glued bands, using either the Heussner or Sinclair type of glue. Our rule has been to apply heavy weight during the first few days and to then diminish it, a practice which is in direct contradiction to the old teaching which applied traction lightly at first with gradually increasing weight. We are convinced that shortening due to muscular contraction is more easily, quickly, and permanently controlled in this way than by the older method. In using glued bands, traction through a joint has as far as possible been eliminated by applying the bands above as well as below the level of the knee. In this way relaxation of the ligaments of the knee-joint—a most annoying complication which may exist for six months or more after union—has been largely avoided.

The ideal form of traction is skeletal, as less than half the weight is required, the control is absolute, the uncertainty of the amount of traction lost on skin and deep fascia is eliminated, and in our experience the patient is more comfortable. Where possible, this traction should be applied to the lower portion of the femur itself. At times, however, it is necessary to apply it through the ligaments of the knee-joint, using the tibia for this purpose. We have entirely discarded the use of the Finochetto or Chutro band (os calcis traction) for fracture of the femur, because of the superiority of other methods. It has been our rule to use femoral traction whenever the situation of the wound allowed, reserving tibial traction only for those cases in which the wound was situated so low on the thigh that infection of the traction wound from this source seemed possible. With the exception of two early cases of the series treated during the summer of 1917, in which we used Steinman pins through the lower femur, femoral traction has invariably been made with ice-tongs. Tibial traction has in all cases been made with a Steinman pin driven through the tibial shaft on a level with and just posterior to the tibial tuberosity. Of the two forms of traction, that applied to the femur is infinitely superior, as no pull is exerted on the ligaments of the knee-joint and the joint can be actively and passively used almost immediately after application, a point of great importance, not only in relation to the eventual function of the knee, but also in the nutrition of the affected thigh during the period when bony union is taking place.

A few words in regard to the form of tongs and the method of using them may be of interest. After using a number of different types, the ones shown in Fig. 6 were adopted as giving the best results. They were made at the United States Army Instrument Repair Shop, Paris, from designs submitted by us. The material used was tempered steel 8 mm. in diameter. The distance between points with horizontal bars parallel should be 7 cm., as it has been found that with the points embedded in the femur

for a quarter of an inch this inter-point distance almost invariably allows rotation without pain. It is important that the points are not too sharp, as otherwise there is a tendency for them to become embedded too deeply in the bone. By following this precaution, we have found it unnecessary to place between the handles of the instrument any device to prevent their approximation. Incidentally this elimination reduces the difficulty and expense of manufacture. The outward bowing of the two limbs of the tongs is essential, if motion at the knee-joint during their period of application is to be obtained.

The method of application has been to make a small stab wound on either side of the lower thigh, being careful to pull the skin first a trifle above the points at which the tongs are to grasp the femur. This stab wound passes to and through the periosteum, is vertical in direction, and should be of sufficient length so that after the application of the tongs there is no pressure of skin on metal. The tendency is to make this stab wound too short. In the absence of infection, it is this pressure which causes discomfort. The point of application should be on each side about one finger breadth in front of the hamstring tendon and should meet the femur just above the point of greatest prominence of each condyle. The points are driven home into the shaft a distance of a quarter inch, a characteristic sound being obtained when the required depth has been reached. After proper application there should be no difficulty encountered in raising and lowering the handles. With tongs of the dimensions above given, such difficulty indicates that a site too high on the femoral shaft has been chosen, the tong points thus approximating each other too closely, with a resulting lack of parallelism of the transverse bars. The small sterile dressing about the tong wounds is usually not disturbed until the removal of the tongs. Immediately after insertion the tong handles are tied together with a bit of bandage. Traction having been once applied, it has been our rule never to release it until the tongs are removed, not only for the sake of the fracture but also for the comfort of the patient. We have wholly discarded the use of Steinman pins for femoral traction.

For tibial traction the Steinman pin has been used. A stab wound is made on the inner surface of the leg on a level with and about three-quarters of an inch posterior to the tibial tubercle, the pin inserted and driven through the bone until it can be felt beneath the skin on the outer side of the leg. The skin over this point is then pulled slightly upward and the second stab wound made. Care should be taken that the pin is driven in at right angles to the tibial crest and, with the toes vertical, parallel to the table.

Skeletal traction can be applied with local anæsthesia, but a general anæsthetic is infinitely preferable. We have been in the habit of employing inhalation ethyl chloride, carrying out the entire procedure usually in the patient's bed without assistance and no further armamentarium than

tincture of iodine, a scalpel, a hammer, and two sterile towels. With a general anæsthetic of short duration, such as ethyl chloride, the procedure requires but a few minutes, and at the same time the extent of traction and the angle of the splint needed to overcome the overriding and correct the deformity can be accurately determined. With more careful technic and more available time, even the slight amount of infection which has occurred in this series should be eliminated. Since using skeletal traction extensively, we have given up the use of the Hennequin band as being too difficult in application and cumbersome in control.

Of the 57 cases in which skeletal traction was employed, ice-tongs were applied in 39 cases to the femur; Steinman pins in 2 cases in the femur and 14 cases in the tibia; and in 2 cases tongs were first applied in the femur, were removed too early, further skeletal traction was found necessary, and Steinman pins were inserted in the tibia. There are thus in all 59 examples of skeletal traction in 57 patients. It is of interest to summarize the early results of this treatment.

There were 41 cases of ice-tong (caliper) traction. In 7 of these the tongs were removed before they had accomplished their purpose, the cause of removal being either amputation, the necessity of sudden evacuation, or death. The average time of traction in these cases was ten days. None were infected.

In 12 cases (29 per cent.) the tongs were removed because of infection or fear of infection about the point of application. This percentage at first sight seems rather high. As a matter of fact, there was but one *real* infection in the series, a man with a profusely suppurating compound femur who developed a hæmolytic streptococcus sepsis, was amputated and died. At autopsy pus could be expressed from a suppurative knee-joint through a tong hole. Even this was not a clear cut case attributable to tongs, as the joint was quite possibly metastatic and the tong hole infected from it. In the remaining 11 cases the crusting and slough which almost invariably are present to a certain extent seemed a little too great and the tongs were accordingly removed before they otherwise would have been. In none of these cases was there a serious infection, nor were there any resulting cases of osteomyelitis. There was not a case, with the exception of the one just mentioned, in which the question of the involvement of the knee-joint even arose. In these 12 cases a traction time averaging 21.25 days was obtained, a distinct gain.

In 22 cases the tongs were left *in situ* until it was felt that their purpose had been accomplished. The average number of days traction obtained in these cases was 34.86. On removal of the skeletal apparatus, traction was maintained either by glued bands or by an anklet. This change was never made until the traction weight could be safely reduced to a small amount, a reduction which could be made much earlier in the course of treatment as the result of heavy initial traction.

The experience with Steinman pins has been almost identical. In 27 per cent. of the cases the pin was removed earlier than it otherwise would have been because of infection or fear of infection. In none of these cases was the infection of any moment. There were no cases of osteomyelitis. The average traction time before removal was 30.20 days as compared with the remainder of the cases in which the traction time averaged 40.20 days.

The tongs are readily removed without anæsthesia and practically without discomfort. As the Steinman pin is rather apt to be a bit more painful, we have been in the habit of using a primary nitrous oxide anæsthesia for its removal.

We will cite two cases as illustrating what can be accomplished with skeletal traction where glued traction faithfully attempted has failed of its purpose.

The first case (Case 57) was admitted to our service nineteen days after injury with a badly comminuted fracture at the junction of the middle and lower thirds of the femur. He was treated in a slightly bent Thomas splint with glued traction until his ninety-sixth day. During this entire period there was a constant and increasing tendency to posterior bowing or "dishing." It was practically impossible to control by traction alone and could only be partially controlled by the use of an inverted saddle arrangement giving upward pressure directly on the upper end of the lower fragment. By the ninety-sixth day "dishing" could no longer be prevented. On that day his displacement was as shown in Fig. 8, lateral bedside exposure. Ice-tongs were inserted in the femur and at the end of four days his position was as shown in Fig. 9, practically perfect. It will be noted that no change was made in the angle of the splint at the knee. At the end of four days tong traction was replaced by glued traction which maintained without difficulty the position attained by the use of tongs.

Case 114 is even more striking. This fracture, practically a transverse one of the mid-third of the femur, occurred in a well-known aviator from a fall. The fracture was compound. He was admitted to and operated upon in a French hospital, where he remained for forty-nine days before being admitted to our service. There was never any lateral displacement, his position as shown in an antero-posterior plate practically always remaining as shown in Fig. 10. His antero-posterior displacement was, however, marked, Fig. 11, taken on admission, showing a displacement equal to the diameter of the shaft. Ice-tongs were immediately inserted in the femur and after three days his position had improved to the extent shown in Fig. 12. Unfortunately, the remainder of the series of plates on this patient are not available. The end result in this patient was practically perfect, there being on consolidation possibly a trifle too much anterior bowing, a position infinitely to be desired to that of a "dished" united femur.



FIG. 7.—Before the use of tongs.

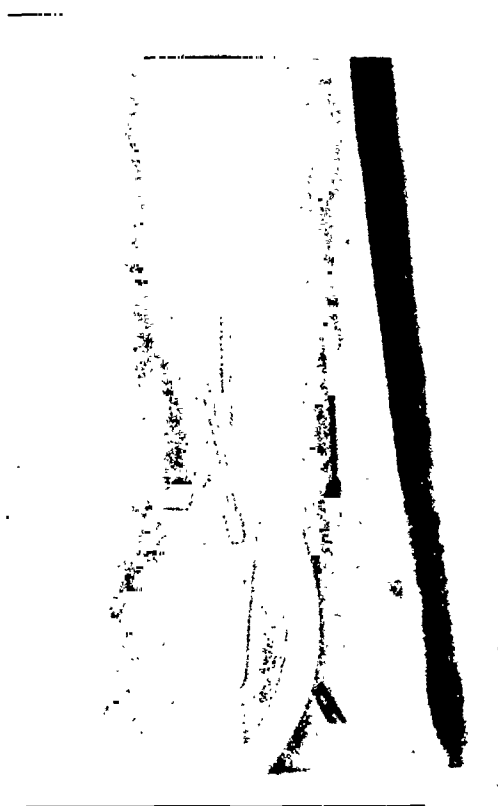


FIG. 8.—After application of tongs, and before lost sequestrectomy.



FIG. 9.—Anterior-posterior view. Never any change.



FIG. 10.—On admission.



FIG. 11.—Same as fig. 10, after tongs were applied for two or three days.



FIG. 12.—Same as fig. 10, after a long application of tongs.

FRACTURE OF THE FEMUR

SUSPENSION

With the exception of an occasional case received in plaster of Paris—always from a French hospital—and rapidly evacuated because of his good condition and the rush of work, all of the cases of this series have been treated by suspension and traction. For definitive treatment we still prefer in the majority of cases the full-ring Thomas splint, reserving the Hodgen (anterior) type of splint only for those cases having high posterior wounds not readily adapting themselves to the pressure of the Thomas ring. The half-ring hinged Thomas (Blake-Keller), while admirably adapted to transportation, has not proved satisfactory for bed treatment because of its constant tendency to ride upward on the buttock. No description of the details of the mechanical suspension and treatment of these cases will be given, the reader being referred to previous articles published on the subject.

WOUND TREATMENT

The treatment of the wound has varied for the individual case and has depended more on general surgical principles than on the teaching of a single school such as the Carrel-Dakin. We are definitely of the opinion that the majority of properly operated wounds progress more quickly and favorably if dry rather than wet dressings are used. For drainage purposes we prefer soft rubber tubing with an inside bore of about a quarter of an inch. The cases operated "up the line" and received by us shortly after operation showed when dressed in this manner far less gas gangrene and serious infection than did those cases packed with gauze, irrespective of whether the gauze was packed loosely or tightly or whether Carrel tubes were used or not. In practically every suppurating compound fracture of the femur, especially those above the lower third, it is well to provide posterior stab drainage just below the gluteal fold, infection frequently spreading toward and gravitation assisting in localization at this point.

LATE OPERATIVE TREATMENT

The late operative treatment resolves itself into the opening of abscesses, the removal of sequestræ, the occasional removal of retained foreign bodies giving symptoms, and most rarely the secondary closure of the wound of the soft parts. Abscesses should be opened as far as possible posteriorly. With preventive early stab wound drainage just distal to the gluteal fold, fewer operations for secondary abscesses will be found necessary.

Sequestræ should be removed when loose. The operation should be made a formal one, done with good exposure and under direct vision. It has

been our experience that even with the most careful X-ray work the pre-operative and operative findings do not always agree. Bone appearing most certainly dead and separated under the X-ray may be found at operation attached and viable, and loose ivory sequestræ found at operation may not have been seen in a good pair of stereoscopic plates. If possible, it is wise to perform the sequestrectomy with the splint still in place and with traction maintained. Refracture can thus be avoided. By careful clean operative technic under good exposure, *all* sequestræ can frequently be removed at one sitting, thus obviating the necessity of further operation at a later date. In the majority of instances it is the overlooking of already present sequestræ rather than the later death of bone which makes subsequent sequestrectomy necessary. Terminal sequestræ should be removed only when complete separation has taken place. They can often be knocked loose by the sharp blow of a blunt instrument. Too early removal simply insures the death of more bone.

Secondary suture of compound fracture wounds is a dangerous procedure and irrespective of bacteriological findings is rarely to be advised. It should never be done in the presence of a sinus, and if properly done with complete dissection of the scar tissue, a potential sinus is immediately established. It has not been allowed in any of the cases of this series, but we have seen disastrous results following such a procedure in other parts of the body.

Foreign bodies overlooked at the primary operation should be sought for and removed later only if giving rise to pain or if associated with abscesses or sinuses. In these latter cases it will often be found that it is a small bit of clothing rather than the metallic foreign body which is at fault. It has been our habit to personally fluoroscope these cases in two planes and to then depend on the electro-vibreur for localization in the open wound. Using this technic, very few magnetizable bodies have not been found. There is enough magnetizable metal in the casing of a German bullet to vibrate with this instrument. Bullet forceps we have discarded. In their place we prefer a finger and a dull Volkmann spoon.

MORTALITY

Of the 131 cases, 26 died, a mortality rate of 19.8 per cent. The causes of death in these cases were as follows:

Gas gangrene	7
Gas gangrene with secondary hemorrhage	2
Gas gangrene (late) after sequestrectomy	1
Streptococcus sepsis	13
Streptococcus sepsis with tetanus	1
Tetanus	1
Lobar pneumonia	1

FRACTURE OF THE FEMUR

Thus gas gangrene was responsible for 34.4 per cent., sepsis for 53.8 per cent., tetanus for 3.8 per cent., and lobar pneumonia for 3.8 per cent. of the total mortality.

The deaths occurred during the following periods after injury: First week, 3; second week, 3; third week, 8; sixth week, 2; seventh week, 1; eighth week, 2; ninth week, 1; tenth week, 1; eleventh week, 2; twelfth week, 1; fourteenth week, 1; sixteenth week, 1. It will be noted that the heaviest death rate occurred during the first three weeks, and that during the fourth and fifth weeks no deaths occurred. Of the early deaths, 7 were due to gas gangrene alone and 2 others to secondary hemorrhages in gas gangrene cases. There were three early deaths from streptococcæmia, and one each from tetanus and lobar pneumonia.

With the exception of one acute gas gangrene flaring up after a sequestrectomy and dying in the eighth week, all the late deaths were due to the streptococcus. There was one late death from tetanus, but this case also had a positive streptococcus blood culture and at autopsy showed multiple streptococcus foci.

This mortality rate is altogether too high. We have already (pages 478 and 480) itemized 19 deaths which we considered avoidable. Others were unquestionably unnecessary. Tetanus should never be allowed to play its part. With adequate hospitalization and transportation facilities, gas gangrene should be eliminated as a contributing factor. The streptococcus as a problem in wound and subsequent systemic infection can up to the present time only be combated by adequate and early operative procedure. Some of the later manifestations must be controlled by amputation, not too long deferred.

CONCLUSIONS

1. A compound fracture of the femur should be operated upon and held for a month, or immediately transported without operation to a hospital where definitive treatment can be carried out. It is an injury of war whose mortality rate is high and whose late results are often crippling. It is an injury to which a sufficient amount of attention is not paid, possibly because often associated at first with relatively small wounds which to the unpracticed eye do not forebode serious results. But it is from these wounds, no matter how small, that the danger arises. Closed fractures of the femur are not of particular danger. Given an associated local wound of the soft parts, and the prognosis becomes immediately worse. And given a combination of the two with an inexperienced surgeon doing inexperienced surgery and an inexperienced "triage" officer indiscriminately evacuating the cases, and the prognosis becomes distinctly bad. We are of the opinion that these cases should either be operated upon and held at an advance hospital for at least a month, or else given priority in transportation and immediately evacuated to a hospital in the rear which can be reached in less than twenty-four hours after injury and in which the patient can be held for at least four weeks.

2. The chief danger lies in infection, gas gangrene in the early weeks and streptococcus in the later weeks. Both can be best combated by early, adequate, and radical surgery.

3. Bullet fractures are practically as dangerous as are those by shell fragments. The occasional bullet wound may be observed without operation, the shell wound never.

4. Those fractures splitting into the hip- or knee-joints are infinitely more dangerous than those involving only the intermediate portions of the bone. Those involving the hip should probably always be amputated and then disarticulated. The majority of those involving the knee will need resection or amputation.

5. The primary operative procedure should be radical to the point of apparent brutality. We have never seen too large an incision. We have seen many pitifully inadequate ones.

6. Amputation should be done oftener and earlier. Too many attempts are made with results disastrous to life to save worthless limbs.

7. The ideal form of traction is skeletal, and this form of traction is practically without danger. Femoral traction is superior to tibial traction.

8. If more care were paid to operative treatment, less would be heard of the chemical treatment of wounds. Such treatment would be unnecessary. General Cuthbert Wallace¹ of the Royal Army Medical Corps, after tracing the rise and fall of the various antiseptics which have been advocated since 1915, deprecates their use, and speaking of the surgery of wounds of war, closes as follows: "I think now we have come to our senses. People talk about revolution in surgery. It is a return to sanity—to ordinary civil practice. You will find that the more war surgery approximates to civil surgery the better it will be. . . . The improvement that has taken place in the wounded is simply due to the fact that one now does what one was taught to do in the days of one's surgical infancy."

We feel that this paper could not be complete without a word of appreciation of the man under whose guidance the treatment of these cases has been. Without the constant support, professional wisdom, and personal stimulation of Colonel Joseph A. Blake, Commanding Officer of the hospital and later Surgical Consultant of the District of Paris, the work must inevitably have lagged and the mortality rate risen. To work under him was a pleasure, and to go to him for advice and assistance always resulted in valuable help and encouragement. The American people and especially the troops who, when wounded, had the good fortune to come under his command, owe to him a great debt of gratitude. As an executive officer he was always just, as one with a trained surgical mind and hand he was unsurpassed, and to his staff he was always a friend.

¹ *The Medical Bulletin*, Par. 1918, I, 364.

THE DISINFECTION OF VITALIZED TISSUES AND THE HEALING OF WOUNDS WITH CHINOSOL AND SALT*

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THE objective is to bring positive and convincing proofs of the healing value of chinosol in combination with salt.

Chinosol is pure normal oxyquinoline sulphate. *In vitro*, though a powerful antiseptic, it is very little germicidal. A 2 per cent. solution did not kill staphylococcus aureus in twenty-four hours. Its disinfectant action on vitalized tissues is therefore probably due to the excitement by it of physiological stimuli to bring nature's forces of resistance to the fore.

Salt was combined with chinosol by the writer through the influence of the writings of Col. Sir Almroth E. Wright¹ relating to salt in the treatment of wounds.

Clinical Experience.—Examples of cases treated with chinosol and salt are as follows: Primary union in incised wounds, as, for instance, a case of cut tendons of the wrist; cases of acute suppuration, as one of cellulitis of the leg covering an area about the size of one's hand, due to colon bacillus, with sloughing interior, in which, with the use of a solution of 2 per cent. chinosol and 5 per cent. sodium chloride, the opposing surfaces of the abscess cavity were almost completely united on the ninth day; the healing of a whitlow with bone involvement without destruction of the tendons (function returning) and with union of the soft parts to the area of exposed bone, the latter having taken place by the tenth day, using a solution of 2 per cent. chinosol and 0.85 per cent. sodium chloride; the filling with granulations, in about five weeks' time, of a bone cavity about 7 inches in length in an expanded lower portion of the shaft of a tibia, resulting from an operation for osteomyelitis, the whole medullary portion of the bone having been removed, treatment having been by a daily application of gauze wet with a solution of 2 per cent. chinosol and 0.6 per cent. sodium chloride for two hours; the healing of a pelvic fistula 6 to 8 inches in length, by injections, at first daily for one month with a solution of 2 per cent. chinosol and 5 per cent. sodium chloride, with which treatment the fistula became reduced to $2\frac{3}{8}$ inches in length, later having been completely closed with the use of the tincture of chinosol; the cicatrization of a deep wound entirely encompassing the anus, the result of the separation of a slough, with high retraction of the anus above the skin surfaces of the buttocks, so that

* Foreword to an uncompleted paper read before the N. Y. Surg. Soc., Feb. 12, 1919.

¹ Wright, A. E.: Lancet, 1915, ii, p. 1009; 1916, i, p. 1203; 1918, i, 831.

in three and one-half weeks' time the anus was pulled down and united even with the surrounding skin, treatment having been by the daily application of gauze wet with a solution of 2 per cent. chinosol and 2 per cent. sodium chloride for about one-half hour; the complete removal of a deep slough filling the base of a large carbuncle of the neck, which had been incised, with the adhesion of the undermined skin edges almost everywhere to the surface of the ulcer underlying them, by the fourteenth day, using a solution of 2 per cent. chinosol and 0.85 per cent. sodium chloride.

A chinosol ointment and a tincture of chinosol have important uses. The ointment (℞ chinosol grains vi, sodium chloride grains ii, lanolin and vaseline āā ʒss) rubbed in for four or five minutes once in two or three hours, has proved a pretty reliable agent with which to abort beginning hair-follicle infections. The tincture (℞ chinosol, 2 per cent., and sodium chloride grains iss to the ounce in 80 per cent. alcohol) applied once a day to the skin around a furuncle, after having removed the grease with a fat-solvent, will prevent infection of neighboring hair follicles.

The technic is simple, application of the chinosol-salt aqueous solution in suppurating and granulating wounds which are accessible being made by means of gauze which, when the wounds are discharging, is left in place between daily dressings, but when the wounds begin to granulate healthily with little discharge, should be removed in two or three hours following the dressing, to permit collapse of the wounds. The solutions used in this class of wounds contain 2 per cent. of chinosol with either 0.85 per cent. or 5 per cent. of sodium chloride. The combination of this strength of chinosol with the hypertonic salt probably promotes cicatrization to a greater degree than does that with the iso-tonic salt, while the latter combination probably promotes the growth of granulations more than does the former. These solutions on contact with the wound cause a burning sensation which quickly passes away.

The healing of blind tracks of soft parts may be facilitated by injecting the tracks once in six or eight hours through tubes having no punctures, introduced to their bottoms, for which purpose the 2 per cent. chinosol solution having the 5 per cent. salt content is probably the preferable solution of the two. The tincture of chinosol (℞ chinosol 2 per cent. and sodium chloride grains iss to the ounce in 80 per cent. alcohol) has seemed particularly advantageous for the healing of blind fistulæ *in ano*, though with a different technic, it being injected into the track two or three times at fifteen to thirty minute intervals each day.

For the control of sepsis in a draining empyema case, the solution of 2 per cent. chinosol with the 5 per cent. sodium chloride content is recommended, one ounce of which may be injected into the cavity daily, to be retained by posture, following preliminary washing with salt solution. In one case the use of a 5 per cent. salt solution for the preliminary washing seemed to avail more toward cicatrization and healing of the wound than had nor-

DISINFECTION OF WOUNDS WITH CHINOSOL AND SALT

mal saline. Wright has shown that a preliminary wash of a pus-secreting surface with physiological salt solution to remove the albuminous substances, gives an after-coming antiseptic an opportunity to reach the bacteria. Before dressing a wound, the surrounding skin is first wiped with McDonald's solution (alcohol 60 parts, acetone 40 parts, to which 2 per cent. of pyxol is added).

First-aid treatment is effected either by packing the wound with gauze saturated with a solution of chinosol iv grains to the ounce and 0.85 per cent. sodium chloride, which may be left in place for twenty-four hours before repairing or redressing the wound, when the same solution should be used again, or by simply sponging the wound freely with the solution during the operation for its immediate repair. The above gauze pack, after remaining in a fresh wound for twenty-four hours, often adheres to well-nourished tissues. Hypertonic salt should not be used in a fresh wound which is to be sutured.

In both old and fresh wounds which gape, it is advisable to interpose a piece of rubber tissue between the gauze which brings the chinosol salt solution into contact with the wound and the external dressings, in order to prevent abstraction of the solution into the latter.

Animal experimentation was done to prove the value of chinosol as a first-aid disinfectant. In the animal experiments the wounds were constructed as pockets between the superficial and deep layers of the superficial fascia in a dog's back. These pockets, when made blood-free, would absorb the solution very freely no matter what was the strength of the salt, but when the tissues were infiltrated with blood the absorption of the solution would be slower or sometimes there would be none at all.

The instances in which primary union followed the disinfection of a scientifically infected wound, where the infection preceded the disinfection, were not frequent. One case which gave encouragement to the work was that of a dog infected with staphylococcus aureus, having used as much of a twenty-four hour culture as could be taken up by a piece of gauze about 1 by 1¼ inches square, crumpled up, which was left in the wound for thirty minutes, the wound then being disinfected with a solution of chinosol grains vi to the ounce and 0.6 per cent. sodium chloride, in which primary union took place in the disinfected wound, while from the control wound on the opposite side an extensive cellulitis developed, which resulted in a large area of superficial necrosis with ulceration extending from near the backbone forward to the anterior median line.

In a recent series of experiments consisting of 12 dogs, in which the lymphatics leading from *wound pockets* between the layers of the superficial fascia, *uncontaminated with blood*, were first infiltrated with the disinfectant solution before infecting the wounds for thirty minutes with as much of a virulent twenty-four hour culture of staphylococcus aureus as could be absorbed on a piece of gauze about half an inch square, crumpled up, and the disinfectant solution was applied to the wounds again following the

infection, the wounds having been finally sutured primarily, these same wounds in seven of the animals united by primary union, while the controls all suppurated. The strengths of chinisol used in this series of animals were grains iv and vi to the ounce, and 2 per cent., and of sodium chloride, 0.85 and 0.6 per cent.

In two similar experiments with *blood-infiltrated wounds*, in which solutions of chinisol grs. vi to the ounce in combination with 0.6 per cent. and 0.85 per cent. sodium chloride respectively, were used, each of the wounds thus treated exhibited an area of dark gray staining of its fatty interior, due to a change produced in the infiltrated corpuscles in the course of from fifteen to thirty minutes by the action of the chinisol, and both of the wounds suppurated, pure staphylococcus aureus having been found in the pus from each, while the control wounds, also infiltrated with blood, both united by primary union. These results led to a study of the action *in vitro* of solutions of chinisol and salt, on washed blood corpuscles. In this connection, it is of interest that two *sterile* blood-infiltrated wound pockets in the subcutaneous tissue of a dog, treated with a solution of 2 per cent. chinisol in combination with salt, with resulting areas of dark gray and gray-black staining, following primary suture, united by primary union. With the use of the first-aid solution (chinisol grs. iv to the ounce and 0.85 per cent. sodium chloride) in experimental wounds into which blood had flowed, a smoky yellow color and occasionally a light grayish tinge have been noted, usually affecting the loose connective tissue joining together the superficial and deep layers of the superficial fascia, which at the same time has become the seat of an œdema resulting from an infiltration of it by the solution. In fresh traumatic wounds, staining of the tissues attendant upon the use of the first-aid solution has, in a limited experience, not been a feature.

These experiments have shown that the production in fresh wound pockets uncontaminated with blood, of immunity to scientific infection with a large number of virulent staphylococci aurei, by the use of chinisol with iso- and slightly hypo-tonic salt and once by the use of 2 per cent. chinisol alone, has been accomplished in a majority of the instances, which furnishes *proof* of the disinfectant action of chinisol on vitalized tissues. The practical application of this knowledge would be to the first-aid treatment of wounds. Thus it would seem that, if fresh traumatic wounds could, within the first few hours of their receipt, at a time when, as Carrel and Dehelly have shown, bacterial growth has hardly begun, have their open lymphatics blocked with a solution of chinisol and iso-tonic salt, comparable to the lymphatic block with the disinfectant solution preceding the scientific infection with a large number of virulent bacteria in the dog's wounds, that immunity of these wounds, at least to the ordinary pus germs, in the presence of a but comparatively trivial amount of in-

DISINFECTION OF WOUNDS WITH CHINOSOL AND SALT

fection at this early period, could similarly be expected. The lymphatic block of a fresh traumatic wound with chinosol and salt should be superficial, since in the animal experiments an extensive infiltration of the solution into the lymphatics opening into a wound, following scientific infection of the latter, seemed many times to have been the probable cause of extending the infection to a distance from the site of its implantation. Although blood infiltration associated with the use of the chinosol salt solution as described, might be incompatible with the production of immunity against a severe scientific infection in an experimental wound closed by primary suture, yet this same condition would not necessarily be incompatible with producing a lymphatic block against the invasion of the tissues by bacteria or with arresting bacterial growth, in a traumatic wound treated open by the introduction into it of gauze packing saturated with the disinfectant solution, especially when the latter is introduced early before the bacteria have begun to multiply greatly.

Twenty-four grains of chinosol in solution have been infiltrated into the lymphatics of a sterile, fresh wound in the back of a dog weighing 8 kilos, with primary union and without complication.

Miss W. Carey Noble, of the Research Laboratory of the New York Board of Health, has made very careful bacteriological tests with chinosol, which virtually confirm the tests of the Council on Pharmacy and Chemistry² of the American Medical Association.

Dr. Alexander O. Gettler, pathological chemist to Bellevue Hospital and to the City of New York, has done important work on the chemistry of chinosol to incorporate in this report.

Mr. Pro. V. Prewitt, Instructor in Physiology at the New York University and Bellevue Hospital Medical College, has done a valuable piece of work on the action of chinosol alone, and in combination with salt, on blood corpuscles.

The merits of chinosol in combination with salt as a tissue disinfectant can be summarized as follows: Its stability, its ease of application, its applicability to first-aid treatment of wounds, its tendency to dry up pus, its non-irritability when applied in accordance with the technic here advocated, unless possibly after prolonged use; also the facts that it appears not to attack tendons and that it facilitates the separation of sloughs.

² Report on Chinosol of Council on Pharmacy and Chemistry, American Medical Association, Journ. A. M. A., 1910, liv, p. 1801; editorial, p. 1790.

A SERIES OF WAR WOUNDS TREATED WITH DICHLORAMINE-T *

BY PENN G. SKILLERN, JR., M.D.

OF PHILADELPHIA

ON the morning of August 17, 1918, at eleven o'clock, in latitude $42^{\circ} 56'$ N., longitude $30^{\circ} 08'$ W., a depth bomb exploded prematurely on board the U. S. S. ———, bursting into thousands of fragments, which peppered alike objects animate and inanimate, killing four men and injuring twenty-three others. Stretcher-bearers transported the injured to the sick bay, where they were undressed, turned into fresh, clean bunks and given restorative measures, including heat, opium, and fluids. First aid dressings were hastily applied, and when the patients were out of shock tetanus antitoxin was administered.

To cope with this situation there were on board three medical officers, of whom Lieutenant Commander C. K. Winn, U. S. N.—the Senior Medical Officer at that time—directed the author to take charge of the operating room, whilst he and Lieutenant R. M. Krepps, U. S. N., supervised the work in the sick bay. In order to determine the location, nature and extent of the injuries the author had each man in turn placed on the operating table, stripped. He then examined minutely each man from head to foot, dictating to a hospital corpsman standing by the location, nature and extent of every injury as soon as it was encountered. This search revealed injuries, of which those included in the following list were the most important:

List of the More Important Injuries.—Perforation of bowel, 4; penetration of lung, 7; laceration of femoral vessels, 2; laceration of penis and scrotum, 2; laceration of eyeball (extensive), 1; rupture of ear drum, 8; fracture of skull (occipital), 2; fracture of mandible, 1; fracture of humerus, 2; fracture of radius and ulna, 1; fracture of femur, 1; fracture of femur (incomplete), 1; fracture of patella, 1; fracture of tibia and fibula, 2; fracture of tibia, 1; fracture of tibia (incomplete), 2.

This list by no means represents all the injuries, for there were numerous punctured and lacerated wounds of various soft parts. The fractures were for the most part compound and many were comminuted. It is now evident that in the entire group of patients several hundred injuries had to be discovered and dealt with. This search consumed twelve hours from the time of the accident—from 11 A.M. to 11 P.M. After the last man had been examined those who had been set aside for operation were taken up, and the operations were finished by two o'clock the following morning.

* Presented before the Philadelphia Academy of Surgery, April 7, 1919.

WAR WOUNDS TREATED WITH DICHLORAMINE-T

The importance of such a minute, painstaking examination from head to foot in this series of injuries is shown by the following case:

P. A. S., seaman, was carefully and minutely examined from head to foot, but the only injury found was a small punctured wound just below the navel—a puncture whose diameter was no greater than the cross section of a matchstick. The patient complained of no symptoms, yet the probe when introduced reached a depth that corresponded to the whole thickness of the abdominal wall. Exploratory celiotomy revealed in the small bowel two perforations of matchstick diameter, while in the mesentery near by there was found a small scale of metal no larger than a grape seed.

In the second case of bowel perforation the two apertures were larger, being jagged holes with at least the diameter of a lead pencil. In this case the jagged edges were inverted, and the two sutured sites were reinforced by free grafts of omentum. The portion of bowel involved was jejunum, and for a few days after operation the patient presented signs of dynamic ileus. This was attributed, however, to reaction œdema of the inverted bowel edges: after several stomach washings the lumen of the bowel restored itself and the ileus disappeared.

In the third case of bowel perforation it was the cæcum that was involved. No operation was attempted because the missile had entered well laterally in the right lumbar region and on its way to the right iliac fossa injured the outer portion of the cæcum, whose contents could freely reach the surface through the large hole made by the missile: a cecal fistula in this situation does not imperil the patient's life. This patient had, in addition, a penetrating wound of the right lung and extensive lacerated wounds of the left thigh and right axilla. He eventually made a complete recovery.

The only fatal case of bowel perforation did not come to operation because the patient was instantly killed, the result of multiple extreme injuries.

Of the seven patients with penetrating wound of the lung six recovered, aspiration of hæmothorax being required in several cases. The fatal case never reacted from the shock of the accident, two hours after which he died, the result of multiple extreme injuries. There was a hole in the left side of his chest through which a fist could be introduced, and it was impossible to seal this hole owing to the patient's precarious state.

One patient had a deep laceration of the dorsum of the penis, just behind the corona glandis. The wound itself was packed to check brisk bleeding from the corpora cavernosa. To prevent subsequent phimosis from reaction œdema of the foreskin, the prepuce was slit transversely just distal to the corona glandis, and the head of the penis was drawn through this slit like a button through a buttonhole, the foreskin dropping posteriorly. A gum catheter was passed into the bladder and retained. The

foreskin proved useful later, when it came to plastic repair of the penis. The wound healed without producing angulation.

The patient with extensive laceration of the eyeball came eventually to enucleation. He was the nephew of a prominent Philadelphia oculist.

There was no operative mortality in this series. The four men who died either were killed outright or succumbed to shock, the result of multiple extreme injuries, within a few hours of the accident. The twenty-three survivors ultimately were either sent to duty or honorably discharged from the service.

The chief purpose in reporting this series, however, is to attest the value of dichloramine-T. Stimulated by the paper on the use of dichloramine-T read before this academy by Lee and Furness on October 1, 1917, the author used this preparation and became a staunch advocate of it and carried with him a quantity to sea. The primary dressing of each wound after the accident consisted solely in filling the wound with dichloramine-T and inserting a short length of rubber dam to maintain the patency of the drainage orifice of the wound. Then over all there was applied and secured a dry, sterile gauze pad. The ship reached port on the twenty-second of August—five days after the accident. The patients were then transferred to a hospital. At the time of transfer *not a single one of the numerous wounds had become infected*—no patient's chart showed elevation of temperature. And several months after the accident the author was told by the surgeons who attended these patients at the hospital that *not a single wound developed the slightest evidence of infection*: what cultures were made from wound discharge invariably proved sterile.

The author wishes to express his appreciation of the action of the surgeons of the U. S. Naval Hospital, Brooklyn, in reserving for him the privilege of reporting this interesting and in many ways unique series of cases.

REMARKS ON THE ETIOLOGY, INDICATIONS FOR TREATMENT, BEHAVIOR, AND POST-OPERATIVE COURSE OF EMPYEMA THORACIS*

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ALTHOUGH the overwhelming variety of valuable statistics recently published have added very much to our knowledge of the etiology of empyema; the writer feels that consideration of the indications, behavior and operations from another angle may be of much use to consider.

The Indications in and for the Operation Are.—1. Pressure dyspnea. Sudden deaths have been attributed by Trousseau, in rapidly occurring copious pleuritic exudates (especially when left-sided), to quick movement or cough, causing torsion of the aorta due to the displacement of the heart, resulting in loss of consciousness and sometimes death from interruption of the cerebral circulation or quick thrombus formation.

Bartels considers that the death in these cases is due to a kinking of the vena cava at its point of passage through the diaphragm, the latter often being spasmodically contracted during violent cough. (No such case has been observed by the writer.)

2. (a) To avoid allowing fluid compression to remain so long as to cause "*permanent changes in and deposit on the pleural surfaces,*" resulting in thickening, contractions or adhesions, also changes in the lung itself consequent on long continued hindrance to expansion; resulting in various degrees of permanent acquired atelectasis.

(b) The early removal of a part of the fluid by aspiration, by relieving pressure on the pleural lymphatics, together with the increased pump-like action of respiration on these vessels, frequently results in complete resorption of the exudate in cases not positively purulent.

3. To remove pus as early as possible after the diagnosis of "true empyema" is made, by thorough "dependent permanent" drainage, saving, if possible, the infection of the neighboring organs in the more acute cases, the breaking through the diaphragm into neighboring cavities, or through the chest wall (*necessitatis*), the hectic fever and possible nephritis or death.

4. A "premature" open operation in pleuritic effusion should be also studiously avoided. (Active acute or subacute lung processes (a) if "*on the same side as the exudate*" are, as a rule (except, perhaps, in certain very rare cases, *e.g.*, a pleuropulmonary abscess), a contra-indication to an early "open" thorax operation (thoracostomy), usually at most only aspiration by a syringe should be done. Active acute or subacute processes (b) "*in*

* Approved for publication by the Surgeon General, U. S. Army.

the other lung and pleura" should also be absent, for an open operation causing a pneumothorax on one side requires that the other lung must be sufficiently normal to do double work.)

5. To avoid very sudden removal of large amounts of fluid in much distended pleural cavities, thereby giving rise to shock, hemorrhage into the bronchi, lung substance, and pleural cavity and perhaps death.

6. To avoid the unnecessary entrance of infection or foreign bodies into the pleural cavity during or after operation.

7. To observe "the strictest possible" measures of surgical cleanliness in even the smallest operations on the thorax.

8. To aid in the return of functional lung activity at and after operations.

(The tension of the exudate, according to Leyden, is exceptionally -2 or $0-$, ordinarily it attains $20+$ and $28+$. This pressure is not alone dependent on the quantity, but is usually less in the debilitated and aged; with rigid thorax and usually greater in young people with more acute infection and elastic thorax. Lemoine remarked that serofibrinous effusions with specific gravity above 1019 are favorable cases; those below 1015 unfavorable, but to-day we resort to the microscopic examination, the culture tube, and inoculation for information as to the etiologic factors.)

9. Inflammatory exudates and empyema may be: (a) primarily pleuritic (hæmatogenous, rare), or (b) secondary to lung infection (usual), or (c) secondary to pericardial or subphrenic abscess, or (d) via penetrating wound of thorax. (Transudates of cardiac, renal or hemic origin are not the subject of this paper.)

10. While microscopic examination of smears and cultures must always be made, it is also very necessary to be conversant with the clinical relation of etiologic factor to *macroscopic* appearance.

(a) *Tubercular Pleuritis*.—The statement that all "exudate" cases are tubercular in which we find no microorganisms at all, as well as those few in which tubercle bacilli are proven present, we know to-day is only relatively correct; *e.g.*, pneumococci, which may be the cause of the exudate, die in the presence of tubercle bacilli quite frequently.

Tubercular pleuritic exudates are often clear, may be cloudy, purulent, or even hemorrhagic. Tuberculosis mixed with pus (streptococcus or staphylococcus) while more rare in "recent" is more liable in advanced pulmonary tuberculosis with cavities or pyopneumothorax, in which latter as well as in some lung abscesses saprophytic infection may also occur. In purely tubercular cases the leucocytosis is low. In simple cases only 9 or 10 per cent. have over 12,000.

(b) *In acute lobar pneumonia* from the pneumococcus alone pleuritic exudates may occur during or after the attack, may be clear but are more often somewhat cloudy, and often slow of absorption; but "true empyema" is comparatively rare, unless "mixed" pneumococcus with streptococcus or staphylococcus be present. According to "Lord," pneumococci are difficult to cultivate from pleural exudate in which they were a

EMPHYEMA THORACIS

coexisting factor; they were cloudy, 53 per cent.; purulent, 16 per cent.; hemorrhagic, 10 per cent.; the rest were clear.

In a cloudy pneumonic exudate one should never be precipitated into "operating" too early; also a few staphylococci in the culture from the aspirated fluid of these may be from the skin during aspiration.

(c) *In bronchopneumonia* the above observations, generally speaking, hold good: (1) In bronchopneumonia the exudate may be tubercular or tubercular mixed infection, or (2) it may be frank localized pneumococcus pneumonia or pneumococcus mixed, or (3) a purely local extension of a purulent bronchitis and bronchiolitis, general or local, to a pulmonary lobule and thence to the pleura with pleuritic exudate often streptococcic, less often staphylococcic; here also is great need for very mature consideration before "open" operating, (4) as to the nature of the exudate, the activity of the process in the same, and also in the other lung, and pleura; when and where to operate.

(d) *In embolic pneumonia* and pleuritis, a pulmonary embolism from a remote area of traumatic non-infectious or infectious thrombophlebitis may be (1) big enough to kill suddenly, or (2) if small and non-infectious absorption with subsidence of all symptoms and healing by a wedge-shaped lung "infarct" without or with resorbable pleuritic exudate or adhesions, or (3) if infectious, one or more abscesses of the lung may occur and either localized single or localized multiple foci of, or a general empyema, demanding one or more operations. (4) Great care is necessary in these operations to avoid coughing, sneezing or vomiting, which might result in the detachment of another embolus.

(e) *Empyema from infection from without (penetrating pleura wound)* e.g., stab, bullet, or, indeed, following paracentesis or premature open operation.

(f) *Empyema may be secondary by contiguity* (1) to a primary pericarditis; or (2) secondary to subdiaphragmatic lesions or subphrenic abscesses breaking upward infecting the pleural cavity, from the liver, kidney, spleen, perforating stomach or duodenal ulcer. One case by Novack was from a suppurating vermiform appendix; and Kelach reported finding Eberth's bacilli in hemorrhagic, and Fernet in serofibrinous pleuritic effusions (*Société Médicale des hôpitaux*, 1891); (3) lastly, chylous from intrapleural rupture of a lymph-vessel.

While Netter's 109 cases, reported twenty-five years ago, of streptococcus, 44; streptococcus and pneumococcus, 2.8; pneumococcus only 26.7; staphylococcus, 1.8; tubercular and putrid, 24.7; are practically the same as the findings of the present day, yet the vast number of recent cases studied and the much wider bacteriologic and clinical experience has so dwarfed our past knowledge as to make it idle to repeat, it yet prompts us to suggest that, though (a) most of the cases studied were undoubtedly empyema, (b) some are probably a general septicæmia with pleural implication.

Behavior of Pleuritis and Empyema.—(1) The opinion of years ago that

streptococci usually only infect the pleura if gaining access to the pleural cavity in sufficient number, and often only then if there is pathological change at some point on the pleural surface (this focus often being too small to detect), and that injections of feeble cultures into the pleural cavity often do not infect the pleura if perfectly healthy, is in a measure true; but (2) that a pleura, though showing no marked change "macroscopically" post-mortem, while large quantities of virulent microorganisms are found on its surface was not in a condition of early inflammation, may be very wrong. (3) Physiologically, the pleural cavity surfaces resorb so very much more quickly the moistening serous fluid that is always passing into it in large quantities, that in health no free fluid remains. (4) In the very early stages of an acute pleuritis secondary to pneumonia the stomata and stigmata of the lymphatics may often be still wide open, and the serum, though passing into the infected pleural cavity in larger quantity than usual, is still *resorbed again so rapidly that no free fluid remains, but is converted in transit into toxins* of much virulence. If early death occur (not necessarily from the pleuritis) no free fluid may be found in the pleural cavity postmortem; indeed, in some cases of very virulent infection death may occur too quickly even for any macroscopic changes to have occurred upon the pleural surface, though very virulent microorganisms may be found in smears and cultures from it.

Prophylaxis.—Prophylaxis against pneumonia and empyema deserves the most careful consideration as to (a) contact infection; in food, clothing, bedding, barracks, or personnel; (b) the dusty air breathed in barracks or houses, on the drill field or in town streets; (c) the care of the respiratory tract mucosa both in health and disease, rhinitis, tonsillitis, bronchitis; (d) the use of antitoxins does not belong to this part of the subject.

Operations.—Where *unresorbable or true purulent effusions* are present we have the choice of several operations, all of which demand the most thorough surgical preparation, and performance by the surgical staff. Bed-paracentesis is too liable to convert a resorbable into an unresorbable exudate or true empyema.

(1) *Aspiration (paracentesis) with the hollow needle* and Dieulafoy's or Potain's vacuum apparatus is the only operation permissible for diagnostic purposes, and where true pus is absent often the only one necessary.

Trocar puncture does not sufficiently fulfil the indications, it being almost impossible to prevent the entrance of air with this instrument. Lefort, Manuel de Médecine Opératoire, many years ago remarked that empyema multiplied under its use. Pus was frequently present at the second, and very generally at the third trocar puncture. I need not to-day mention the great probability of an unclean field and trocar being the cause of the suppuration.

Simple thoracotomy performed early in pleuritic exudate without or with washing out the pleural cavity and reclosure, may allow the entrance of

air into the pleural cavity and is of very questionable advisability. The cases of this kind would in all probability often have recovered without any operation, or, at most, aspiration of a part of the fluid.

The method of using the aspirating syringe as published by the writer in 1894 deserves special reiteration. The aseptic syringe needle should after careful surgical preparation be well buried in the soft parietal tissues (at a point indicated by the physical signs of pleuritic exudate) till the distal opening is entirely covered by the soft parts; "now produce a vacuum" in the receiver, after which the needle can be pushed slowly and carefully onward. Its entrance into the pus cavity is marked by the sudden filling of the syringe. This precaution makes us aware of the exact distance necessary to insert the needle and avoid wounding the lung. The needle should be provided with a "guard" so that its accidental insertion too far is impossible. The aspirating syringe does not permit the entrance of air and makes us independent of the degree of positive pressure. Only sufficient of a vacuum should be maintained to evacuate the fluid slowly through the needle.

(Raising the arm above the head will suffice to keep the skin wound from being in line with the pleural wound.)

Before saying what operation we should do we must also further consider what occurs in pleuritic inflammatory exudates.

1. In very low-grade inflammatory conditions with (1) the resorptive power still unimpaired with (2) the regenerative power only stimulated, (3) interlobar or pulmo-parietal adhesions occur, usually circumscribed over or around the area of primary lung involvement. In the latter case the exudate, if any, may later be resorbed, and perhaps entirely replaced by adhesions.

2. In virulent "local" pulmonary pleuritis the affected area is comprised of three zones: (1) the zone of inhibition (non-adhesions), lying immediately over the pulmonary focus; surrounding this we have (2) the zone of plastic adhesions; and still more peripherally, (3) the zone of regeneration and true circumscribing fibrous adhesions. This third zone (a) becoming strongly adherent, a purulent exudate becomes circumscribed permanently, or (b) if the circumscription is weak it may rupture and a secondary diffuse empyema may result.

3. In very acute cases the infection on the pleura may spread by continuity over the weak plastic and regenerative zones too rapidly for any true circumscribing adhesions to form, so that an unresorbable exudate or true empyema becomes diffuse or general from the beginning.

4. The inflammatory exudate may also, because of the early fibrinous or small cell infiltration, plugging of the stomata and stigmata, be so rapid that the pulmo-parietal pleural surfaces are too rapidly separated, so that adhesions are impossible and the exudate from the first is general or diffuse. (Transudates, being non-inflammatory, are always general.)

5. A virulent diffuse empyema pressing the lung into the vertebral gutter may cause so much infiltration or necrosis of the pleura that after drainage

the infiltration at first, later induration and adhesions, may act as a permanent hindrance to expansion even though the lung be comparatively healthy, or the lung itself may be also involved.

6. *Thoracostomy (vacuum) siphonage* (in which the intrapleural vacuum is still maintained). A "collapsed" rubber drainage tube is inserted between the ribs and sutured in place, the distal end being kept under water in a bottle. This is theoretically perfect, but difficult to carry out successfully always at the best site for dependent drainage. The vacuum favors lung expansion and favors drainage but may affect the inflammatory condition adversely by perpetuating congestion and the lack of rest. Whittemore's work in this connection certainly deserves attention and study. If the lung be already bound by adhesions firmly in the vertebral gutter it will not succeed in a cure.

7. *Simple (open) thoracostomy* (making a permanent fistula between the ribs).

(a) In children with less liability of previous pathologic changes in, and more expansive lung, with greater power of pleural regeneration, and greater flexibility of chest wall, placing a tube between the ribs in the thinner anterior axillary line is often sufficient, but in these, healing is often tardy and only with great deformity. The insufficient dependence of the drainage demands that the pulmonary and parietal pleural surfaces granulate together and literally gradually push the pus out. Pus if at high tension should be evacuated over a period of about two days, the opening being kept elevated and as securely closed as possible by copious wet dressings. After the second day the opening should be kept in the most dependent possible position. Much less shock may be experienced if a portion of the high tension pus is aspirated the day before the operation. The successful needle aspiration site is always a good guide for the open operation site. (b) In adults "selective" rib resection should, with rare exceptions, be the rule (see operation).

8. *Costatectostomy*.—Making a permanent "selective" fistula with resection of one or more ribs.

Just where shall we operate? (a) *In circumscribed empyema* we have no choice, the place of election being immediately over the site of the successful diagnostic needle puncture.

(b) *In empyema secondary to subphrenic abscesses* "breaking upward" we must choose the point that will give us the greatest advantage over both cavities, making counter openings, if necessary, to drain the pleural cavity.

(c) *Primary "multiple" resection of ribs* may be necessary, e.g., Case 2196, Keyes Records, Cook County Hospital, C. S., aged thirty-six, male. "Finding no pus on resection of the seventh rib immediately under the needle puncture site, the next rib below was also resected widely, the hand inserted, adhesions below broken up, and evacuation of a large quantity of yellow, creamy pus, followed by rapid recovery." No. 2287,

EMPYEMA THORACIS

J. C., aged forty, simple atelectatic low-pressure case, no pus flowed out, though it could be clearly seen and discharged itself immediately the patient was turned on his back, with rapid recovery.

(d) *In a diffuse general unilateral purulent exudate*, according to Lefort, we should operate: In a position (1) sufficiently dependent; (2) to avoid the diaphragm. In France the old rule was to choose a point between the ninth and tenth ribs on the left, and eighth and ninth on the right side; but as the diaphragmatic attachments are the same on both sides the rule is not sound. We can readily understand how by following this rule in *paracentesis* the aspiration of an empyema in the narrow complementary pleural space would be difficult, especially on the right side with the liability of piercing and infecting the diaphragm and liver. Certainly to do costatectomy so low is not devoid of risk. I have seen the peritoneal cavity opened by mistake on one occasion in Cook County Hospital by one of the most experienced operators. (3) *In thoracostomy* the two conditions are best fulfilled in general empyema, near the middle of the thorax, fourth to sixth rib. Here the incurvature is greatest posteriorly at a point between the inferior angle of the scapula and the posterior axillary line; here, with the patient in the dorsal position, we have the common junction and lowest point of three inclined planes extending from lung apex, from diaphragm and from vertebræ. (Besides the better drainage afforded (a) in general unilateral empyema, (b) most circumscribed exudates also occur posteriorly, due to the habit of patients lying on the back.)

The resection of a rib is to be preferred in adults, especially in those with more or less rigidity of the chest wall. The unfavorable conditions for expansion already present or which we are about to institute, *viz.*, a collapsed lung, a permanent pneumothorax with atmospheric pressure equal both within and without (instead of the negative within, causing increased lung expansion, and the heavier atmospheric without, causing increased chest wall depression), demands early operation and early total evacuation of pus; for in both *the tube between the ribs (thoracostomy)* and *the rib resection (costatectostomy)*, we have a very much larger space between the "collapsed" lung and the undepressed chest wall to granulate up, and later on contraction must literally pull in the chest wall to the surface of the lung, or the lung out to the chest wall, usually some of both.

In considering the foregoing facts we cannot but recognize the deficiencies of all operative methods. Cases are on record where recovery has occurred by expectoration through a bronchus opening into the pleural cavity, but this bare possibility has no more to recommend it than the spontaneous evacuation by an insufficiently large spontaneous sinus (*necessitatis*) of the chest wall, which in nearly every case has a very tortuous course and is usually in a situation (anterior axilla) in which total evacuation of pus is impossible.

Operation for "general" unilateral empyema as advised in 1892 by the writer of this paper. With all due surgical precautions, the patient is placed in Sims's or a modification of Sims's position, according to the side to be operated upon, diseased side uppermost.

An incision 7 to 8 cm. long, immediately under the inferior angle of the scapula, directly over and along the middle of the rib to resect, extending through the periosteum to the bone. This latter is now carefully pushed off the rib anteriorly and also separated from it posteriorly, the bone ($1\frac{1}{2}$ inches) resected; the edges of skin are now sewn down near to the pleura, to cover the raw surface, and also to maintain the patency of the opening.

The anæsthetic is of importance to consider—a hypodermic of morphine sulphate (quarter of a grain) three-quarters of an hour before the operation may admit of its being performed "under local," or warmed ether may be employed according to "the Rovsing bag" method.

A small incision is now made in the pleura to allow the slow escape of pus. Should the pressure be very great within the cavity, the tearing open of the incision wider, with dressing forceps, can be deferred until the second or third dressing. The insertion of a tube in this operation is not absolutely necessary. *The patient should lie with the wound dependent always; to sit up is dangerous.* (Keyes records, 2618, Cook County Hospital: "Patient was doing so well that on request 'premature' permission to sit up was allowed, and drainage ceased. Autopsy revealed circumscription above the diaphragm.")

The less virulent case is often the most dangerous—the recovery is so rapid that the patient is often allowed to sit up or get up too early. The pus collects in the dependent part of the thorax, regenerative activity occurs above the level of the pus with pulmo-diaphragmatic pleural circumscribing adhesions and entire cessation of drainage, requiring a very bold secondary operation on a patient often in too poor condition to re-operate. The dressing of empyema cases after operation is a matter of the greatest importance. Antiseptic irrigation has its dangers; by it we may unintentionally convert a circumscribed into a general pleurisy or rupture weakened walls, and infect neighboring cavities, even with lethal issue. Solutions strong enough to have antiseptic effects are liable to be toxic, unless the drainage is perfect. We are dealing in most acute cases with a granular surface, that requires only to be early and thoroughly drained to heal; while washing is as little in keeping with these cases as it would be in peritonitis, and though irrigation is favored by some writers so long as the cavity contains putrid material, it is usually an excuse for imperfect drainage. The above references to antiseptic solutions and irrigating are not to be interpreted to include the Carrel-Dakin treatment, of which the author reads excellent reports but as yet has had no experience with.

The principal causes of "perpetual" pleural sinus after operation are:

EMPHYEMA THORACIS

Non-expansion of the adherent pleura and lung, defective drainage, chronic tubercular pulmonary foci, foreign body, necrosis of rib.

(A lung and pleura, especially if the latter is not too much involved, may often still undergo some respiratory excursion immediately after operative pneumothorax is instituted. The spouting of pus at the primary operation is a good sign.)

The possibility of non-expansion of the lung appeals forcibly not only for early evacuation of "true" pus, but an attempt at a careful study of the condition of the lung as to its expansion at the primary operation, which can often be successfully made by inspection through the opening.

(a) The various secondary operations of multiple rib-resection devised by Estlander, Schede and others leave much to be desired. Of Berger's twenty-six thoracoplastic operations ten healed and five were improved. The lung is often so shrunk and adherent against the spine that the secondary extensive "multiple costectomy" operation only is useless.

(b) Delorme, *La Semaine Médicale*, January, 1894, freely opened the chest wall widely, freed the lung from the false membranes that bound it in the vertebral gutter; when functional activity was restored at once, the "pleurotomy" opening being again sutured.

It certainly appears much more rational to aim at restoration of lung function than by the simple resection methods that as often fail as succeed; often only increasing the size of the outer opening, always *increasing the deformity and perpetuating the incapacitation of the lung*.

The early use of Beck's paste in the general pleural cavity in these cases is absolutely wrong.

One case entering my service at Cook County Hospital (after operation and Beck's bismuth paste injection) died an awful death by bismuth poisoning and was reported at length by my senior interne, now Captain Vernon, U. S. Army (*Journal A. M. A.*). Since then like unhappy results have also come under my observation.

The most careful re-consideration of the size and resorbability of the cavity is very necessary before making any rule.

ACUTE DILATATION OF THE STOMACH

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ACUTE dilatation is a somewhat unusual condition, the vagueness of the underlying mechanism and causation of which has stimulated the interest of the surgeon and the experimental physiologist. Indeed, its occurrence following abdominal operation is of startling and serious concern to the surgeon. It is impossible to detail, in a complete and critical analysis, the increasing and voluminous literature of the subject. As it would be futile to repeat and discuss all the factors, I shall, therefore, mention the salient points only, and review several leading articles, in order to orient the reader and to focus the attention on the dominant theories that have been advanced.

The literature of dilatation of the stomach is mainly expository from the clinical viewpoint. There are numerous articles, analytical in scope, and a few experimental and therapeutic. The authors, and they represent the general trend of all who have written on the subject, describe in detail the conditions with which dilatation of the stomach is associated, aptly illustrating a fact common in medicine, that if the mechanism or causation of a lesion is not clearly understood, a multiplicity of theories rapidly arises. The synonyms, "acute gastro-duodenal dilatation," "gastro-mesenteric ileus," "arterio-mesenteric obstruction of the duodenum," "acute gastric paresis," indicate and confirm this confusion. In the discussion of the etiology of dilatation, therefore, the various conditions with which it is associated must be mentioned. Of course, it is by no means proved that these are the exciting causes; indeed, it is possible that in the enumeration of these topics one is merely describing, as it were, the predisposing factors.

It is necessary, in order to obtain a clear grasp of the subject, to mention these factors in more or less detail. It is assumed that the occurrence of acute dilatation of the stomach is favored by prolonged dorsal decubitus. Certain clinical impressions exist which tend to strengthen this view. Excessive post-operative fasting and purgation have been considered auxiliary factors. A relaxed abdominal wall has been mentioned as a predisposing factor. It is believed that by a diminution of the intra-abdominal pressure, the intestines fail to maintain their normal level, assuming, consequently, a pelvic position. The cases occurring during the course of pneumonia have been explained by the propulsive action of the lung; this, aided by the paroxysmal coughing, forces the intestine down into the pelvis. The relation of the duodenum to the

ACUTE DILATATION OF THE STOMACH

lumbar vertebræ is advanced by advocates of the arterio-mesenteric theory as a most important factor. The frequency of the association of dilatation with lordosis, scoliosis and kyphosis, makes it seem unlikely that these spinal deformities are mere coincidences. Indeed, the etiologic relation seems quite direct, so far as clinical reasoning can proceed. According to Piersol, the duodenum reaches its lowest point at a site opposite the fourth lumbar vertebra, over the disc, above or below it. In one-fourth of the cases it is opposite the third. It is rarely opposite the fifth vertebra and, if it is, it is probably pathological.

Since the time of Britton, the subject has received a great deal of attention from English and continental authors. The outstanding feature of the earlier literature is the clear and critical exposition of Fagge. The symptoms are detailed with a mastery characteristic of the English clinicians, the article emphasizing the degree of accuracy of observation in the writings of these older physicians. The etiology is not mentioned, the paper dealing, solely, with the symptoms and pathology. He gathered the few individual case records and notes then existing in textbooks and transactions of medical and pathological societies. As some of these are based on doubtful analysis, they have not been included in statistical analyses. He brought out the important point that acute dilatation of the stomach may arise during various diseases. In describing several cases which came under his observation, he identified the condition as a clinical entity, wholly distinct from chronic dilatation consequent to stenosis of the pylorus. He states that visible peristalsis, so common in chronic dilatation, has never been seen in acute dilatation and that, even if it occurs, it would be almost invisible, for the contractions of the attenuated wall of the stomach would, necessarily, be extremely feeble.

An article by Smith contains illuminating comments and statements, and an analysis regarding the importance of the arterio-mesenteric obstruction. Though this may occur, he believes it is secondary to the primary distention of the stomach and the duodenal grooving is purely an accentuation of the normal anatomic crease. He stresses the fact that no case occurs save but following general narcosis, a point of doubtful value, for there may be a long lapse of time between the administration of the anæsthetic and the actual development of the dilatation. He also maintains that general intestinal paralysis exists, of which the stomach presents a special manifestation. He conducted several animal experiments, which, apparently, were not productive of definite results. He brings out the importance of the vagi in the artificial production of dilatation of the stomach. His animal experiments prove nothing save that division of each vagus nerve, beneath the diaphragm, close to the œsophagus, produced dilatation of the stomach.

The paper of Conner, an authoritative study and analysis of the subject, is a creditable contribution to American medicine. Not only is the general literature surveyed clearly, but each dominant clinical point

is emphasized and evaluated. Moreover, he does not accept the conclusions of previous investigators, but repeats in detail their experiments, amplifying them from the standpoint of technic. Conner's article is an exhaustive and comprehensive study of the then existing literature. Conner has leaned toward the arterio-mesenteric theory. (No doubt, he has been influenced towards the acceptance of this view by the findings in his own personal case.) Moreover, it is evident, from a reading of his article, that he has been greatly impressed by the work of Kelling. Conner, repeating and elaborating Kelling's experimental work, altered the technic somewhat by the introduction of a water pressure apparatus, to determine the degree of pressure necessary to overcome the obstruction in the duodenum. The paper, which is exceedingly stimulating, is sound in criticism and judgment.

It is manifest from a careful consideration of the symptoms detailed by many authors, that a more or less uniform entity exists under the heading of acute dilatation of the stomach. The striking unanimity of the symptoms is characteristic. Nevertheless, from a clinical viewpoint, it is evident that the symptomology of this disease differs from acute mechanical obstruction of the upper intestine. This point was forcibly brought to the writer's attention by a case which he had the pleasure to examine with Dr. Alfred Forman. The patient, a woman, suffered from a volvulus of the stomach. At operation, we found that the upper jejunum was incarcerated in the fossa of Treitz. The stomach, having rapidly dilated from the obstruction and strangulation, turned in its long axis, so that a distinct volvulus took place. The point that I wish to stress is, that though this particular case forms a striking example of acute obstruction of the upper jejunum, the analysis of the symptoms proves that there is a distinct difference between high intestinal obstruction from incarceration or strangulation and acute dilatation of the stomach. The symptoms appeared with extreme suddenness; profound shock, terrific abdominal pain, profuse vomiting, the crisis being reached in a few hours. On the contrary, acute dilatation of the stomach is often of slow development and progress. The onset is insidious, without severe or sudden abdominal pain. The signs of profound toxæmia rapidly supervene. Vomiting is often a negligible factor. Indeed, the condition may persist for days, or even weeks. Moreover, the macroscopic pathology differs markedly. In actual obstruction, the stomach is extremely swollen, red, congested, as in the case of a loop of obstructed intestine in a strangulated hernia, while the stomach, in acute dilatation of the stomach, is toneless, white or gray in color and presents absolutely no evidence of strangulation or incarceration. These two facts, the wide difference in the symptomatology and the distinct variation of the stomach and duodenum, as ordinarily understood, are in no way comparable to acute intestinal obstruction, as illustrated by a hernia of the upper jejunum in the fossa of Treitz. Reflection upon these points tends to convince the

ACUTE DILATATION OF THE STOMACH

writer that the cause must be sought in a deeper study of disturbed physiology and not in the older conceptions of mechanical blocking, constriction, or obstruction.

One gains the impression from a perusal of the literature, that the numerous associated pathologic conditions, which have been so minutely recorded, have served merely as predisposing and favoring factors. In general, infection, anæsthesia and trauma form the ultimate analysis. The inference is irresistible that the discussion in the past has mainly concerned the general conditions favorable to the mechanism of production, and avoided all reference to the specific cause. Moreover a large amount of the experimental studies, so meticulously described, consists essentially in post-mortem examination of the stomach and duodenum. A fallacy is evident here, for the dead stomach is not, in any manner, comparable in its mechanism to the living. A striking feature of the recorded post-mortem examinations is the persistent emphasis placed on the toneless state of the stomach. It would seem from a superficial examination that the entire musculature is relaxed or paralyzed. An attempt to analyze this loss of tonus in the stomach and duodenum would involve, necessarily, a discussion of the physiology of tonus in general, a subject extremely comprehensive and one which, as yet, has not been sufficiently elucidated or developed in detail.

It has been maintained that duodenal dilatation does not always take place and is not always an integral part of the lesion, a view partly sustained by an examination of the autopsy records; for many of these protocols fail to mention or describe the size or appearance of the duodenum. It is manifest that this evidence is of no moment, because post-mortem examinations, particularly of patients who have died from surgical operations, are frequently incomplete and hasty. Indeed, many times, the autopsies are nothing, more or less, than superficial examinations conducted through the original operative incision, by an interne, to satisfy his natural and very creditable curiosity as to the cause of death. A fleeting view is obtained of the viscera and the essential point noted, but the vital details needed and requisite for a complete understanding of the disease are overlooked. It is a practice, admittedly, of scientific value but of extremely limited scope.

Another factor of extreme importance is that unless an autopsy is performed with extreme care, the position of the intestines may be disturbed and the actual state of the duodenum, which ordinarily is difficult to inspect, owing to its deep position and obscure anatomical relations, may be overlooked. Dilatation of the duodenum, therefore, which is not a distinctive condition, may be undiscovered, owing to the conditions present and prevailing at autopsy. Naturally, if the examining physician or pathologist has the lesion clearly in mind previous to incision, it is conceivable that special care would be taken to note the state of the intestine. There is no doubt but that rough handling and coarse manip-

ulation of the intestine, incidental to the autopsy, disturbs greatly the visceral relations. It is possible, when an autopsy is made, that slight alterations in the position of the abdomen may loosen the viscera, or even eliminate or obscure the obstruction. In view of this likelihood, the abdominal organs should be hardened *in situ*, and, at a later date, be carefully studied.

The term—arterio-mesenteric obstruction—is open to misconstruction, for it creates the impression that the artery is the constricting factor. Evidence exists, relating especially to the width and position of the pressing band or area of hyperæmia and necrosis on the wall of the duodenum, which tends to disprove this belief.

The persistent character of the duodenal obstruction is generally ascribed to the traction action of the stomach, which by virtue of its extreme weight and pressure displaces the entire small intestine and the pelvis, producing, as an indirect result, a distinct drag on the mesentery.

The term—acute dilatation of the stomach—is not complete or correct, because it fails to connote the dilatation of the duodenum, which is just as marked and, probably, the most important, or perhaps even the primary lesion.

In the ANNALS OF SURGERY, Doctor Cohn reported a case and the bibliography of acute dilatation of the stomach, secondary to trauma or infection of the extremities. He made a thorough search of the literature and was able to find but ten authentic cases in which acute dilatation of the stomach followed injury, infection, or an open operation of either the upper or lower extremities. It is evident, therefore, that the condition is extremely rare. In order to stimulate interest in this puzzling condition, the following case is reported:

A. M., age thirty-four, admitted to Fordham Hospital, December 30, 1916. Died March 15, 1917. The previous and family history of no moment. On December 30, 1916, while inspecting the overhead trolley wires of the New York Central Railroad at Williamsbridge, the patient made a contact with 1100 volts. The shock disturbing his balance, he fell from the cross-piece of the trolley pole to the ground, a distance of forty feet. When found, the patient was unconscious. He was quickly brought to the hospital. On examination, the patient proved to be well-developed, with large muscles. The eyes were equal; pupils contracted; marked subconjunctival hemorrhage of the left eye; lacerations of the left eyebrow, requiring four silk sutures, and slight abrasions of the face. He complained of pain in the chest. Auscultation revealed distinct crepitus over the fifth rib in the mammary line. Palpation showed no tenderness or false point of motion. Abdomen negative. The left leg was everted; marked swelling of the upper half of the thigh; patient could not raise heel from the bed; definite false point of motion, crepitus and tenderness elicited in the upper part of the left femur.

ACUTE DILATATION OF THE STOMACH

Measurement disclosed one-half inch shortening. The patient received the general treatment for shock and the fractured limb was immediately immobilized in long, lateral, moulded, plaster splints. X-ray report by Doctor I. Landsmann, January 13, 1917: The radiographic examination of the left femur disclosed the presence of an intertrochanteric fracture of the neck of the femur, with an upward and outward displacement of the upper fragment. The great trochanter is again fractured from the upper fragment. There has also been a fracture of the horizontal ramus of the os pubis, with no separation of the fragments. No fracture of the ribs.

Diagnosis.—An irregular, comminuted, intertrochanteric fracture of the left femur; fracture of the pelvis.

January 4, 1917, the temporary dressing was changed. The patient's condition remained excellent. Dressings applied to the lacerated eye.

January 15, 1917, operation (Dr. Anthony H. Harrigan). Ether narcosis. An incision was made over the great trochanter and the site of fracture was exposed. Extreme difficulty was met in the attempt to secure reduction of the fragments. In order to obtain reduction, four small fragments had to be removed. Following this a Lane plate was applied, using four screws. The inner fragment, attached to the great trochanter, was sutured to the shaft-bone with kangaroo tendon. In order to maintain reduction and to retain the fragments in alignment, the limb was encased in plaster in the position of partial abduction. The patient withstood the operation very well. No shock or hemorrhage. About ten days following operation, however, temperature gradually rose. It was evident that the operative wound was infected. Daily dressings were instituted. Despite this the suppuration continued. The plate became exposed in the wound.

February 17, 1917, the patient was brought to the operating room and under ether narcosis, the Lane plate was removed, the incision was well opened, irrigated with iodine water and then packed with sterile gauze. The patient improved slightly following the removal of the plate. Temperature, however, continued and he complained of severe pain in the left knee-joint. A Volkmann splint was applied to prevent eversion of the leg. The femur was partly immobilized with sandbags. Daily dressings failed to relieve the pain in the knee-joint; the discharge, however, was not profuse.

March 9, 1917, the patient began to vomit at frequent intervals. The ordinary remedies were used for the first two days. These failed, however, to stop vomiting. Stomach washes, gastric lavage, was then instituted. The vomitus was a dark greenish fluid and of large amount. The temperature which had been elevated became subnormal and continued so until his death. The patient vomited every day from this time until the 15th, the day of his death. After each attack of vomiting the stomach was washed. He complained absolutely of no pain, whatsoever, during this stage. Hypodermoclysis 500 c.c. given every eight hours. Patient was placed on a

Bradford frame with the view of immobilization of the limb, with a minimum amount of discomfort to the patient from dressings and lifting. During the night of the 9th, he complained of pain in the gastric region; nausea and vomiting. Large amount of light brown fluid with curdled masses. Morphine and bismuth given.

March 10, 1917, patient seemed slightly relieved. He soon, however, vomited a large amount of dark brown fluid. Stomach wash. Patient very weak. Hypodermoclysis saline solution, 500 c.c., every eight hours. Gastric lavage.

March 12, 1917, the patient was removed from the Bradford frame. Vomited during the entire day, greenish fluid. Patient very weak. Hypodermoclysis saline solution, 500 c.c., every eight hours. Murphy drip and digalen. Continued to vomit at intervals, small amount of greenish-black fluid. Restless.

March 13, 1917, vomiting still continues. Gaunt. Face pinched. Vomits continuously. Has been removed from the Bradford frame. Temperature still subnormal. Hypodermoclysis continued. Gastric lavage. Patient very low. At night vomited amount of greenish-black fluid, about six ounces.

March 15, 1917, condition low. Digalen and hypodermoclysis. Vomited small amount of greenish-black fluid. Patient very weak. Unconscious. Pulse thready. Died at 8.50 P.M.

On this day, visible peristalsis was distinctly seen when the abdomen was flicked with the finger. A central protuberance would slowly form; left to itself, it seemed to disappear by vermicular movements. The movements appeared to be unmistakable and absolutely indicative of acute dilatation of the stomach. As the urine continued in abundant amount and proved negative on examination, uræmic poisoning was excluded as the cause of vomiting. A septic embolus of the brain, likewise, owing to the absence of distinctive head symptoms. Moreover, the temperature was depressed and the signs of general sepsis lacking. Diagnosis: Acute dilatation of the stomach.

URINALYSIS

December 31, 1916.—Transparency, cloudy; reaction, acid; casts, 0; erythrocytes, —; color, amber; albumin, 0; leucocytes, 0; amorphous sediment, flocc. ppt., specific gravity, 1030; glucose, 0; pus, 0.

January 16, 1917.—Transparency, clear; reaction, acid; casts, granular cylindroids; erythrocytes, 0; color, amber; albumin, faint trace; glucose, 0; leucocytes, pus, few; amorphous sediment, 0; specific gravity, 1020.

January 21, 1917.—Transparency, clear; reaction, acid; casts, 0; erythrocytes, —; color, amber; albumin, 0; leucocytes, pus, few; amorphous sediment, flocc. ppt., specific gravity, 1020; glucose, 0.

February 18, 1917.—Transparency, cloudy; reaction, acid; casts, 0; amorphous sediment, 0; color, amber; albumin, trace; leucocytes, 0; specific gravity, 1020; glucose, 0; erythrocytes, 0.

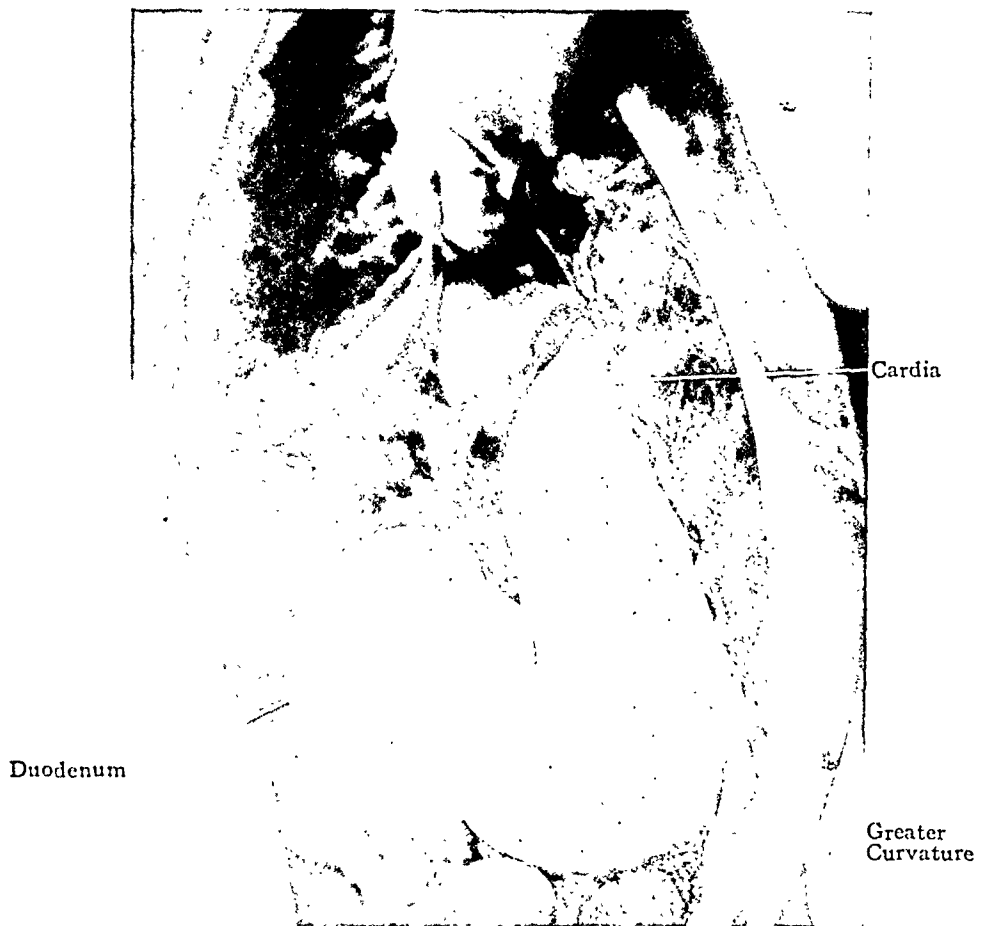


FIG. 1.—Showing tremendous enlargement of stomach and duodenum.

ACUTE DILATATION OF THE STOMACH

BLOOD EXAMINATIONS

January 19, 1917.—Leucocytes, 22,200; polynuclears, 97 per cent.; number cells cnt., 100; lymphocytes, 3 per cent.

January 21, 1917.—Leucocytes, 8200; polynuclears, 68 per cent.; number cells cnt., 100; lymphocytes, 32 per cent.

February 8, 1917.—Leucocytes, 9800; polynuclears, 76 per cent.; number cells cnt., 100; lymphocytes, 14 per cent.

February 11, 1917.—Leucocytes, 9600; polynuclears, 81 per cent.; numbers cells cnt., 100; lymphocytes, 19 per cent.

February 15, 1917.—Leucocytes, 11,000; polynuclears, 83 per cent.; number cells cnt., 100; lymphocytes, 17 per cent.

February 20, 1917.—Leucocytes, 11,200; polynuclears, 82 per cent.; number cells cnt., 100; lymphocytes, 18 per cent.

February 25, 1917.—Leucocytes, 11,000; polynuclears, 81 per cent.; number cells cnt., 100; lymphocytes, 19 per cent.

Autopsy (Dr. George Hohmann), April 4, 1919, 11 A.M. Body is that of a man, 5 feet 8 inches in height, weighing about 130 pounds; very much emaciated. Abdomen retracted. Bed-sore on each buttock. Left leg was about four inches shorter than right. An open incision with drain inserted was noticed in the region of the right hip (result of previous open operation for reduction of fracture).

Usual incision from suprasternal notch to pubes. Abdominal examination: The undisturbed viscera showed the stomach and duodenum greatly dilated, the latter extending to a point anterior to the vertebral column. Beyond this point the remainder of the intestinal tract was normally inflated. The transverse colon was displaced downwards a distance of two or three inches. Position and size of all other viscera appeared normal, except spleen, which was pushed upwards about one inch. Examination showed a tremendous distention of the stomach (Fig. 1). The duodenum was also greatly dilated, up to the point where it was crossed by the superior mesenteric artery. The surface of the duodenum presented a peculiar mottled appearance, causing it to greatly resemble pancreatic tissue. The superficial veins were distended. The stomach was grayish-white in color. It resembled a large ovarian cyst. The first part of the jejunum was normal in size and appearance. There was no free fluid present in the abdomen and no signs of peritonitis. The pylorus was distinctly patent. The stomach and duodenum showed no evidence of ulceration or carcinoma. The stomach lay in a vertical position, with the pylorus forming a short hook, similar to the end of a hockey stick. The creasing or the obstruction of the terminal duodenum by the superior mesenteric artery was clearly seen. The dilatation of the stomach and the duodenum extended precisely to the point of crossing of the superior mesenteric artery. The duodenum immediately distal to this point was absolutely normal in calibre. The duodenum was of the "U" shaped type and its various anatomic divisions could be clearly identified. As the transverse colon was not distended, its relation to the duodenum was distinctly evident. The autopsy showed no signs of sepsis or evidence of pyæmia. The cardiac sphincter was closed, but the pyloric was open and much dilated. The duodenum was dilated and its wall thinned. This dilatation extended to a point anterior to the vertebral column, where the duodenum was crossed by the superior mesenteric artery, the latter producing indirect pressure at this point and causing partial, and, indeed, almost complete, constriction of the intestinal lumen. The duodenum to the left of this was displaced downwards a distance of two or three inches. Position and size of antrum or calibre. Size of stomach, 23½ cm. long; diameter, 11 cm.; at pylorus,

6x3¼ cm.; duodenum, 14 cm. long, 5x6 cm. diameter. Liver, spleen and kidneys negative. Chest examination: Right lung was covered with a number of old pleural adhesions; lungs otherwise negative. Heart and pericardium: On gross examination, appeared negative. Head: Brain and membranes negative.

Microscopical Examination: The mucous membrane of the stomach showed a moderate round-celled infiltration, with congestion, but there were practically no other changes visible. In the duodenum a similar inflammatory infiltration is present, extremely marked in circumscribed areas, where the polymorphonuclear cells are massed together. The submucosa is slightly infiltrated. The muscularis shows no changes.

In passing, however, it may be pertinent to point out that one predisposing etiological factor was present—an alteration in the posture. The symptoms began soon after using the Bradford frame. The vomiting developed following his being placed on the Bradford frame. The evening of the first day he complained that the sharp edge of the canvas, at the upper margin of the hole cut for defecation, pressed and cut him. The nurse, therefore, took the lower end of the frame from the end of the bed and placed it on the mattress. The upper end had rested on sandbags, placed at right angles, to secure a solid support. These bags were lowered, but not removed. This resulted in the frame being placed in a moderate degree of inclination, a point overlooked by the nurse. The following morning, when visiting the patient, it was found that as a result of the inclined position, he had slipped down the frame, so that the buttocks lay in the hole. The vomiting occurred immediately after this. This slight reversed Trendelenburg position may have permitted the small intestine to sag downward into the pelvis and to drag on the mesentery.

In the case which is detailed, it is interesting to recall the actual conditions preceding the development of this lesion. In a patient suffering from an infected wound, of moderate severity, acute dilatation of the stomach develops to an extreme degree. Profound toxæmia occurs and death takes place. But many days had elapsed since the administration of the anæsthetic. It is impossible to ascribe this case to the excretion of ether or chloroform into the stomach. The sole etiologic fact in the history is the rapid occurrence of acute dilatation following the placing of the patient on a Bradford frame.

This incident, which would place this case in the category described by numerous authors, as following spinal scoliosis, kyphosis, etc., is strikingly similar to the case in which acute dilatation of the stomach developed, following the application of a plaster-of-Paris jacket, to a patient with scoliosis. The sliding of the patient, with the buttocks projecting into the opening in the canvas, produced a marked bending of the spinal column. This acute lordosis, if the expression be permitted, was rapidly followed by the development of acute dilatation of the stomach. It is needless to state that this etiologic factor, the alteration in posture, merely offers, as it were, a mechanical preparation and could

ACUTE DILATATION OF THE STOMACH

not be the actual cause. The specific causal element is, no doubt, more profound and physiological.

In order to record another case, but one, I believe, to be of an entirely different nature, the following history is recorded:

The patient came under my observation in Fordham Hospital, January 15, 1918. The operation performed was a Gilliam suspension. At the conclusion of the operation, which had proceeded smoothly and without hindrance, I noticed the stomach bulging into the wound. The incision was about four inches long and situated midway between the os pubis and the umbilicus. The stomach was intensely engorged. Its color was brown or mahogany. The blood-vessels on its surface were deeply injected. To the exploring hand the stomach felt like a large cyst and it appeared to be at least five times its normal size. I could detect no evidence of a pyloric or duodenal kink, or cicatrix. The greater curvature, when the stomach was at its maximum distention, was but four inches from the os pubis. The stomach rapidly collapsed and at once returned to its normal size following the introduction of a stomach tube. At no time during the operation was the swallowing of air detected. This point was corroborated by the anæsthetist.

A second case occurred at St. Francis Hospital, when I operated on a young married woman for chronic appendicitis and salpingitis. During the operation, the stomach presented into the wound. At the time of maximum distention, the greater curvature measured two inches from the os pubis. Nothing noteworthy occurred, save that during the induction of narcosis, the patient became cyanosed and the tongue was forcibly pulled forward.

The personal case of Lee was one of acute dilatation taking place during an operation (gastro-jejunostomy) for duodenal ulcer. Death took place at the end of the operation. He describes in detail other instances in the literature of acute dilatation of the stomach occurring during the actual performance of an abdominal operation. Luckett's case is striking, in that the patient was observed swallowing air. This places some of these cases in a peculiar classification and tends to separate them from the other group. To my mind, we are dealing with a condition which is fundamentally and radically different from acute dilatation, which occurs in the course of acute infections, as a post-operative sequel, or as a result of a disease or injury to the extremities. It is possible that this type of dilatation results from a difference of intra-abdominal and atmospheric pressure. This conception is purely theoretical. When the abdomen is opened and the air enters the peritoneal cavity, the cardia sphincter may relax and the air, normally present in the œsophagus, passes rapidly into the stomach, until the pressure—*intra and extra gastric*—is equalized. This view is worthy of consideration and experimentation.

The study of the gross pathology of acute dilatation of the stomach is incomplete. More information is desired concerning the question of equal involvement of the anterior and posterior walls of the stomach. Also, the relation of the transverse colon to the dilated stomach needs clarification. The cases in which a definite physical obstruction at the pylorus has been described are, probably, not true instances of acute dilatation of the stomach. Though several writers speak of rupture of the muscular layers and of minute hemorrhages in the mucous and submucous layers, the histology remains obscure. Conner found that thirty-eight per cent. of the cases had a part or whole of the duodenum dilated. In this connection, one must again point out that it is possible, owing to hasty investigation, or lack of care on the part of the examining physician, the actual appearance and calibre of the duodenum may not be accurately noted. Moreover, the precise point at which the dilatation ceases is not known. In many of the analyzed cases, the dilatation ceases where the duodenum is crossed by the mesentery, a distinct ring of necrosis existing at this point. In three cases, the dilatation involved the beginning of the jejunum.

A noteworthy point mentioned in the sixty-nine autopsy records collected by Conner is the large size of the stomach. In numerous cases the greater curvature reached to the symphysis pubis. The color of the stomach may be purplish-red, gray, or bluish-white. Some writers describe a characteristic cylindrical form, producing a more or less "U" or "V" shaped organ. An interesting group of cases is associated with disease or injury of the spinal column. These instances have been associated with disease and deformity of the spine, particularly Pott's disease, with dorsal kyphosis, uniform kyphosis of the whole dorsal and lumbar regions, dorsolumbar scoliosis and rhachitic dorsal kyphoscoliosis.

From the clinical and analytical viewpoint, the theory of primary mesenteric occlusion of the duodenum has been widely discussed. At the point of intersection of the mesenteric root and lower duodenal segment, there exists, even under normal conditions, a constriction, which, as a result of distention of the stomach and duodenum, becomes more distinctly manifested. A major part of the discussion centres round the relationship of the superior mesenteric artery to the terminal duodenum. Conner, as a result of his anatomical studies, finds this condition common. Moreover, the case of the author aptly illustrates this point. This important anatomical finding naturally has led many observers to consider acute dilatation of the stomach an obstruction, caused by the superior mesenteric artery constricting the terminal duodenum. The frequency of its occurrence has strengthened the conclusion.

Conner supports the theory of mesenteric obstruction. He concludes that it is frequently found, according to autopsy records, and that enormous quantity of fluid vomited, or obtainable by lavage, indicates high

ACUTE DILATATION OF THE STOMACH

obstruction. The high obstruction prevents the usual reabsorption of the stomach, liver and pancreatic secretions.

Facts elicited at autopsies must, however, be subjected to strict scrutiny. One should recall that autopsies, particularly in surgical cases, are often done hurriedly, perhaps through the original operative incision, owing to failure to obtain consent for a complete examination. Furthermore, they are frequently performed by internes, whose sole desire, in contradistinction to the trained pathologist, is to find or establish one definite point.

Conner made special anatomical studies to solve these problems. After moving the entire small intestine and attaching a cord and weight to the mesentery, he filled the stomach with tap water, in order to determine the degree of pressure to overcome the duodenal obstruction. The observations, though subject to inherent errors, appeared to prove that traction of the mesentery can produce obstruction of the duodenum, a view previously advanced by Albrecht. It is necessary, however, in this theory, to grant the postulate that the small intestine falls into the pelvis. The question as to whether changes in the abdomen favor the descent of the intestine into the pelvis is not understood.

Conner believes that the most common cause is the constriction of the duodenum produced at the base of the mesentery by the superior mesenteric artery. Moreover, he expressly states that, in his opinion, for the constriction completely to prevent the passage of fluid and gas, it is necessary that the small intestine lie, mainly, in the pelvis. Unquestionably, this added qualification greatly weakens the original force of the arterio-mesenteric theory. In short, the obstruction must be complete before dilatation occurs. It is evident that the traction of the mesentery would be immeasurably increased were the small intestine in the pelvis. The crucial point in the discussion is, does the small intestine lie in the pelvis? No evidence exists to prove this. The post-mortem records are hardly admissible, because they fail to present the actual conditions occurring during life. The position and arrangement of the small intestine unquestionably depend, to a great extent, upon the amount and nature of the intestinal contents and the degree of tonus. Without a precise knowledge of these factors, it is impossible to come to a logical conclusion regarding the actual dragging or traction of the small intestine.

There has been some minor discussion as to whether the constricting element is the mesentery or the artery. The evidence consists, mainly, in the width or area of the affected duodenum. The weight of opinion is that it is caused by the root of the mesentery. Some adherents of the mesenteric theory resort to subsidiary theories in order to explain the permanent nature of the obstruction. They maintain that the stomach, becoming distended, descends and compresses the duodenum.

Extensive experimental investigations have been made by Kelling, who initiates his research on the assumption that dilatation of the

stomach cannot occur if the stomach retains the power of contraction, over-distention being avoided by the onward or upward propulsion of the contents. A valvular closure of the duodenum, the result of a slight kink, may follow artificial distention, pathological adhesions predisposing to this form of kinking. Though the kink usually lies above the opening of the common bile duct, it may lie below. In the latter instance, the bile and pancreatic secretions are found in the stomach contents. Kelling is extremely enthusiastic in the defense of the theory, but the experiments appear somewhat crude, and in no manner comparable to the mechanism of the living stomach. Furthermore, he fails to mention the details and technic of the inflation method and does not state succinctly whether the condition occurs so rapidly that the stomach or intestine is unable to withstand increased pressure, or whether a distention so sudden is possible during life. The inflation, naturally, would have to overcome the normal tonus of the intestine, an effort which would require a high degree of air pressure. Kelling believes that there are individuals in whom spontaneous occlusion of the cardia and of the duodenum occurs from over-distention of the stomach and that this leads to acute dilatation. Fermentation forms an important auxiliary factor.

As the literature records numerous cases in which the greater curvature reached the symphysis pubis, Kelling stresses gastropptosis, especially the low position of the cardia, as an important predisposing factor, and one possibly explaining the tendency to valvular closure of the cardia. He believes, also, that a low position of the pylorus, or pyloric stenosis, local peritonitis in the region of the pylorus and the duodenum, and especially narcosis, predispose to kinking of the duodenum. While Kelling does not support the theory of arterio-mesenteric obstruction, he believes that a distended stomach may push the small intestine into the pelvis, creating secondary arterio-mesenteric obstruction. This opinion is qualified, however, by adding that arterio-mesenteric obstruction may, at times, be primary and the kinking secondary. In a series of cadavers, he inflated the stomach through an opening in its anterior wall and found that the cardiac orifice possessed a modified valve-like action, which prevented the air from passing into the œsophagus; but, when the intragastric pressure was markedly increased, the air freely passed into the œsophagus. After ligating the œsophagus and inflating the stomach, air passed freely through the duodenum; but, in certain instances, an obstruction occurred from the formation of a sharp kink. This kink occupied various levels of the duodenum. As a result of these investigations, Kelling contends that acute dilatation of the stomach occurs in individuals who possess a tendency to cardiac valvular closure and the production of an obstructive kink in the duodenum. Conner, in repeating these experiments, failed to find the obstructive kinks so distinctive or frequent. Kelling made additional experiments in dogs. Through a gastrostomy incision, acute dilatation of the stomach was produced by inflation. When a certain degree

ACUTE DILATATION OF THE STOMACH

of distention was attained, vomiting resulted and the dilatation was relieved. If the animal were narcotized, the stomach could be distended to the bursting point, without the least escape of air through the œsophagus, or without any reflex attempt at vomiting. In an experiment mentioned by Braun, a dog, with a previously made gastrostomy, had the vagi cut in the neck. Twenty-four to forty-eight hours later, he inflated the stomach through the fistula. Nevertheless, the animal was capable of emptying the stomach through vomiting. This experiment, beyond proving that the vagus does not necessarily play a part in the vomiting, or nervous activity of the stomach, has no physiological significance. Moreover, any experiment employing general anæsthesia introduces the influence of narcosis upon the act of vomiting.

Spasm of the pylorus is believed by some to be the essential factor. A superficial review quickly dispels this view, for the pathological records of acute dilatation of the stomach prove positively that the lesion does not stop at the pylorus; moreover, the presence of the contents of the upper intestine in the vomitus demonstrates conclusively that the stomach and the duodenum freely communicate.

Cadaver experiments are fallacious. The physical conditions differ so greatly that all comparisons and distinctions are lost and the reasoning inevitably becomes illogical. In a cadaver the stomach is lax, toneless and consequently shapeless. It must follow that experiments performed in order to determine the tonicity and condition of the sphincters are valueless.

The relation of the sphincters, to the specific cause, has been widely discussed. No doubt the sphincters, both cardiac and pyloric, play a part; but one, unquestionably, contributory and not specific. Kelling, Seidel and Conner conducted experiments in order to determine the rôle played by the cardiac and pyloric sphincters. Their results were indefinite and uncertain. Braun and Seidel state that opening the abdomen caused a cardiac contraction. But it is evident that reflexes may be engendered during the experiment, which may easily alter and affect the normal degree of contraction.

Some authors have laid great stress upon the fact that acute dilatation of the stomach generally follows narcosis. Unquestionably, both ether and chloroform are excreted by the gastric mucous membrane; but, in the unusual cases, particularly that furnished by the author, the interval of time elapsing between the administration of the anæsthetic and the onset of dilatation is so long, in many cases extending over weeks or months, that it seems impossible to establish a specific etiologic relationship.

The subject of high intestinal obstruction received a new impetus from the experimental investigations of Draper. This author, while studying the technic of the triangular twine suture in gastro-enterostomy, noticed that the animals died before the ligature cut through. From this crucial experiment evolved a long series of experiments, which he has

collected and collated in several distinctive papers. In sum, Draper concluded that there was a definite form of high duodenal obstruction which resulted in death from a chemical cause. From this point other investigators, namely, Whipple, Hartwell, Sweet, etc., have conducted subsidiary experiments, mainly, with the view of determining whether the cause of death in high duodenal obstruction was essentially chemical or bacterial. To amplify the latter statement, one means, of course, by chemical origin, that death was independent of the growth of bacteria in the body.

Hartwell and Hoguet conducted a series of experiments on dogs to determine the cause of death in intestinal obstruction. The post-mortems were carefully conducted, all tissue being examined microscopically. Blood and organ cultures were made. They concluded that death is not due to a bacterial infection. Their experiments are somewhat diffuse in that they worked indiscriminately on various parts of the intestine. An important technical advance mentioned is the use of a special clamp to occlude the intestine. They state that transverse division and inversion of the ends produce inflammatory alterations in the walls of the intestine, which vitiate the results and disturb the accuracy of the observation. Hartwell, in insisting that strangulation adds a disturbing factor to the problem, endeavored to eliminate it by devising this special occluding clamp. Simple division and inversion of the ends, according to his view, may produce a local strangulation. Furthermore, he states that at autopsy, there is found a structural change in the wall of the intestine, sufficient in extent to admit a ready absorption of the poison, a point from which he bases his divergence from Whipple.

Sweet has concisely summarized the experimental work of Whipple and Draper, investigators who have studied diligently the cause of death in high intestinal obstruction. In point of fact, Draper was the first to show that high division of the duodenum caused death. Whipple believes that a toxic proteose is the lethal agent. Though Sweet concurs, he suggests that, possibly, the pancreatic secretion plays a part in the production of the proteose.

Hartwell appears as an opponent of Whipple, Stone and Bernheim in maintaining that the poisons isolated by these authors result not from the activity of the mucosa, but occur as a result of injury to the intestinal wall, consequent to the unavoidable operative trauma and manipulations. In this connection, it is interesting to recall the criticisms of Sweet, who points out that Whipple, in his study of a closed loop, was, in reality, dealing with high intestinal obstruction as practiced by Draper; and that it is not unreasonable to assume that the duodenal poison is secreted into the closed loop.

It is definitely known that the intestine normally contains microorganisms potentially pathogenic and that their activity and virulence are augmented during obstruction. Also, that bacteria may migrate

through the wall of a congested or injured intestine. It is not clear, however, whether bacteremia may occur, unless there be a primary peritonitis, though it is conceded that strangulation greatly favors the migration of bacteria. The experiments of Hartwell apparently prove that death is not caused by bacterial infection. He inclines strongly to the theory of dehydration. For one to keep this clinical picture in mind, he is impressed by the great similarity which it bears to that presented in experimental high ligation of the intestine in animals.

Indeed, from the experimental studies of Draper, Whipple and Sweet, it would appear definitely proved that a toxic proteose is the actual lethal agent in high intestinal obstruction. This is true provided peritonitis does not occur, for in this case infection is the determining factor. It is possible that the pancreatic secretion plays a part in the production of the toxic protein. In point of fact, the symptoms of acute pancreatitis are strikingly similar to those of high duodenal or jejunal obstruction, and it is a generally accepted belief that the intoxication in acute pancreatitis results from toxic bodies engendered during production.

The intoxication theory has been approached by injecting the normal contents of the stomach and the intestine, and the injection of the intestinal contents oral to the site of the obstruction. Naturally, this material contained bacteria. It is assumed, however, that the rapid death excluded bacterial infection. The conclusion is that the injection of these contents causes death. These experiments are extremely crude. The chief objections to the intoxication theory are based on the dissimilarity of the symptoms of acute intestinal obstruction and those following the injection of the intestinal contents into the blood; the lessened absorbing power of the obstructed gut; and, that many bodies, for example, peptone, if injected into the blood are lethal, while if placed in the intestinal tract are innocuous.

The cardinal point is that death is a chemical one. Moreover, if the ligation of the duodenum is made at a point more than 35 c.c. from the pylorus, death is obviated. The question intimately concerns the activity of the proteolytic enzymes of the pancreatic juice of the succus entericus. Also, one must consider the activity of a lipase capable of breaking down lecithin into neurine and choline which are highly toxic bodies.

Leaving this question aside, for the moment, of the cause of death, there is, unquestionably, a striking similarity in point of symptoms, between acute dilatation of the stomach and high duodenal obstruction, as seen in animal experiments. This view, a personal one, was acquired from a series of experiments on cats, conducted by the writer, under ether narcosis, in which the upper intestine immediately below the pancreas was ligated with plain tape. In these experiments, an effort was made to determine the effects of the hypothetical poison of high duodenal obstruction on the ganglion cells of the myenteric plexus. This, necessarily, included a study of the spinal cord and the peripheral nerves,

the vagus, sympathetic and splanchnic. These were to be studied from the histological and physiological aspects. Of course, in performing these animal experiments, the element of asphyxia was considered in the production of abnormal contractions.

Stimulated by the experimental investigations of Keith and Alvarez, the writer formed a hypothesis to explain the mechanism of acute dilatation of the stomach. The hypothesis consists merely in the assumption that acute dilatation of the stomach is caused by paralysis, inhibition, or failure of function; and, that this paralysis, inhibition, or loss of function is toxic in origin. This hypothesis rests upon the assumption that there exists in the wall of the duodenum, a nerve plexus which is capable of acting like a nodal centre; from which arise the impulses that initiate the degree and extent of peristalsis of the duodenum. Assuming this, a series of experiments on cats were conducted in order to determine if intestinal obstruction could produce anatomic alterations in the myenteric plexus. In these cats and a few dogs, following ligation of the duodenum immediately below the border of the pancreas, symptoms developed in all instances as described by previous workers in this endeavor. At the death of the animals, the duodenum and stomach were removed and subjected to histological investigations. In general, these results have been indefinite, owing to the technical difficulties offered to the histologist.

But it was extremely remarkable in studying the course of intestinal obstruction in these cats, to note that the general symptoms, so uniformly accepted and supposedly characteristic of acute intestinal obstruction, such as pain, and prostration, were generally lacking in these animals. These observations strengthened the belief that strangulation is, unquestionably, the dominant factor in the production of the acute or dynamic symptoms of intestinal obstruction. Another factor at play in the animal experiments is the question of ether, which may, possibly, modify or minimize the effects of the strangulation. In a word, a cat, in which intestinal obstruction has been produced under ether anæsthesia, the characteristic and usual symptoms significant of acute intestinal obstruction are lacking. The clinical picture observed in these animals resembles greatly that described by Draper as occurring in dogs. Instead of the clinical picture so often seen by the surgeon in occlusion, the clinical picture resembles that which is seen in acute dilatation of the stomach, where the occurrence of toxæmia is indisputable. There is no analogy, in the slightest, between the conditions observed and those seen in adults suffering from acute intestinal obstruction of the upper intestine. No pain appears evident. Whether this is due to the psychology and mental standards, or, perhaps, more likely to the influence of the anæsthetic, is not certain. Unquestionably, the element of strangulation is the determining one in the production of the intense and dominant symptoms of acute intestinal obstruction as seen in the human.

The problem should be considered from the newer conceptions and

views of the physiology of the stomach and duodenum, a topic which, in recent years, has received additional stimulation from the suggestive work of Keith and Alvarez. These authors coincide fundamentally in their conceptions concerning the peristalsis of the stomach and duodenum. Keith, in particular, in emphasizing the striking analogy between the stomach and the heart, pointed out that both organs are developed from a simple muscular tube and receive a double nerve supply, and from this analogy assumes the existence of a definite nodal system in the intestinal wall, comparable to the neuro-muscular mechanism of the heart muscle. From the developmental viewpoint, the stomach and duodenum have a different origin than the small intestine. In a word, there is in the duodenum a meeting or fusing point between the fore and mid gut. It is possible to conceive a bundle of muscle connecting the two divisions of musculature, permitting the transmission of impulse or waves.

Without attempting a too intricate explanation or defense of the theory certain physiological points may be elaborated. The nerves entering the intestine form a plexus between the longitudinal and circular muscular fibres, called the intramuscular, or myenteric plexus of Auerbach. From this plexus, fibres pass obliquely through the circular muscular layer, in order to form within the submucous layer, the plexus of Meissner, from which branches pass to the villi to supply the glands. The plexus of Auerbach has definite microscopic ganglia.

The exact physiology of the intestinal muscles is unknown. Two theories exist, as in the case of the heart; one, the myogenic, the other, the neurogenic. The same anatomic basis for the theories and discussion likewise exist here, as in the case of the heart. It is generally assumed that the rhythmic movements are myogenic in origin, while the highly coördinated movements are dependent upon the intrinsic nervous system. The activity of the intestine, as a whole, is, probably, dependent upon the integrity of the myenteric plexus.

The so-called myenteric reflex, or law of the intestine, a principle discovered by Starling, is of interest in this connection. The anatomic basis of its mechanism depends upon the integrity of the myenteric plexus. Bayliss and Starling also proved that the law of the intestine maintained, even when all the nerves, from the central nervous system to the intestine, had been cut. An histologic experiment by Meek tends to confirm this view. In this experiment, Meek, following division of the intestine, studied the time of regeneration and proved that the myenteric reflex reappeared only when the regeneration of the intrinsic nervous apparatus was complete. These experiments tended to prove that the basis for this reflex existed, in all probability, in the plexus of Auerbach. Gaskell states that Kronecker and Meltzer, in their investigations of the peristaltic contractions of the œsophagus, antedated the later work of

Bayliss and Starling, who by means of the enterograph confirmed and recorded the law of the intestine.

Later experiments were made by Magnus, who studied an isolated piece of intestine suspended in Ringer's solution. After the two layers of muscle, longitudinal and circular, were separated by means of a needle, spontaneous movements occurred only in the longitudinal muscles. The circular layer remained quiescent. Upon stimulation, it gave a local contraction, but no signs of a contraction wave. In order to verify these observations, he made an histologic examination and found that the whole of the plexus of Auerbach was attached to the segment containing the longitudinal muscles. From this he agreed with Bayliss and Starling that the plexus functions after its complete separation from the central nervous system. From this one may assume that the myenteric plexus plays a dominant part in the peristalsis and tonus of the intestinal musculature. The plexus of Auerbach acts somewhat like an independent nervous system. Embryological researches, however, prove that it results from an outgrowth of cells of the spinal cord. Bayliss considers the plexus of Auerbach as the seat of the reflexes of peristalsis.

The smooth muscle fibres which compose the musculature of the sigmoid, like all non-striated muscle fibres, have the power of originating contraction, and according to Keith, the initiating impulses are collected and correlated in certain neuromuscular nodes. Failure of coördination of these in that centre is supposed to result in a most curious and interesting phenomenon, the so-called idiopathic dilatation of the colon, or Hirschsprung's disease. Many instances of this condition have been recognized since the attention of American surgeons was called to it by Finney. The disease is similar in origin to cardiospasm at the cardiac orifice, pylorospasm and stasis at the ileocaecal valve.

The question of whether the duodenum is indispensable to life and whether it has specific physiological functions, is still unsolved. An obstacle in the decision of these problems is the technical difficulties offered to the experimental surgeon in the removing of the duodenum. The relation of the pancreas and the stomach, and the question of the pancreatic and biliary ducts, increase the scope of the surgical and technical problems. Years ago Pfluger stated that when the duodenum is removed diabetes occurs. More recent investigators report that this contention is unsound. On the other hand, some maintain that the duodenum is as necessary to life as the suprarenals or the parathyroids. In a recently reported experiment, a dog was kept alive for three months after complete removal of the pyloric end of the stomach, the duodenum and the upper jejunum.

Acute dilatation of the stomach has been explained as a paralysis or inhibition of the nerve centre, either peripheral or central. If local, then its occurrence following operations on the gall-bladder is easily explained. The general and customary improvement in distention, following the

removal of the drain, is explained by the relief of irritation of the local nervous mechanism in the bowel wall. But, among the numerous theories advanced to explain the cause of death in intestinal obstruction, is one ascribing the central nervous system as the primary factor. The dominant symptoms, rapid pulse, ataxia, low blood-pressure and dilatation of the splanchnic vessels, point suggestively to an involvement of the medullary centres. It is comparatively easy to state that the patient's condition is caused by paralysis of the stomach and duodenum. A closer analysis, however, demonstrates that this statement possesses no scientific value, because paralysis is a general term and meaningless in itself. It is readily understood what is meant by the paralysis of a muscle, but the actual specific cause must be known before one could have a clear understanding of the subject. Many authors have viewed the problem as a simple paralysis of the stomach, a view which has received some support from the analogy the condition bears to intestinal paralysis, following abdominal operations.

But in the instances of paralysis occurring as a part of the processes of peritonitis, it is manifest that the phenomena of inflammation which take place within the structures of the wall of the intestines are, undoubtedly, the primary determining causes of paralysis. These changes are demonstrable. One readily can note the exudation, the swelling and the œdema, and it is logical to assume, from this macroscopic picture, that the myenteric plexus is destroyed or injured by the action of the toxins. Simple trauma, consequent to an abdominal operation, may effect results similar to those produced by inflammatory changes; but, in acute dilatation of the stomach, this theory does not, at least in all cases, play a rôle.

It is well known, as above mentioned, particularly from the experimental work of Carrion and Hallion, that division of the vagi, even at varying levels, causes dilatation of the stomach. (In passing it may be mentioned that division of the vagi below the diaphragm in dogs is an exceedingly difficult operation. Accidental opening of the cardia is likely. The vagi may be divided within the chest, but the mortality of thoracotomy in dogs is high.) And from these experiments it was deduced that possibly a toxin acting on the centres controlling these nerves might produce the same result. This view of the nervous origin of the disease is partially substantiated in that the lesion has been noted following injuries to the head and spinal column. Also, the cases complicating pneumonia are explained on the ground that the infection, possibly, through an associated pleurisy, extended to the vagi as they pass through the thorax. Unfortunately, in these recorded instances, no histological examination has been made of the nerves. Such an examination would, undoubtedly, elicit important corroborative points.

In passing, one may say that the view of paralysis of function is advanced to explain many physiological problems. One may recall that within recent years, it was urged and maintained with considerable

plausibility, that paralysis of the vaso-motor centre is the essential mechanism of shock. Recent knowledge, however, proves that this ready-made theory of paralysis generally does not suffice. The phenomenon of inhibition is signally neglected by the enthusiastic theorist.

In order to restrain undue speculation and theorizing, the pregnant observations of Meltzer should be recalled. He points out that the history of physiological experimentation records the inevitable propensity of investigators to ascribe, in a general sense, a failure of function, involving the activity of the nervous system, to exhaustion or paralysis. A classical example illustrating this instance is the theory of paralysis originally suggested to explain the action of the vagus on the heart. Indeed, the phenomenon of inhibition has been emphasized but comparatively recently. If we transfer this dualistic conception of the nervous system, paralysis or inhibition, to the subject of the stomach, one may, with a fair degree of reasonableness, ascribe the causative mechanism as inhibitory in nature, in place of exhaustion, depression, or paralysis.

The mechanism of the abdominal reflexes is not clearly understood. Inhibition, unquestionably, plays a large part in their production, a point demonstrated by Meltzer in his experimental and physiological investigations concerning the causation of shock. The problem is, admittedly, a complicated one, because of the intricacies of the peripheral and central nervous system. Primarily, the question concerns the question of the vagus and the splanchnic nerves; but, in addition, the activity of the so-called myenteric plexus increases the scope of the problem.

Conclusion.—There is in both stomach and duodenum an intrinsic nervous system which for the sake of simplicity is called the myenteric plexus. In various places it is so arranged as to form distinct nodes. This nodal system is supposedly the point where the impulses leading to peristalsis are initiated. At present there is no direct evidence to prove that marked alterations occur in the myenteric plexus as the result, or coincident with duodenal obstruction. A marked disadvantage lies in the absence of a technical measure which can actually reproduce acute dilatation of the stomach. Moreover, the animals best suited to these experiments, such as the cat and the dog, offer peculiar difficulties to the histologist in his efforts to secure suitable specimens for microscopic study of the myenteric plexus. From the standpoint of the histologist, the white rat is, perhaps, the best animal for this particular work; but, from the viewpoint of the experimental worker, the rat is particularly unsuitable for experimental operation.

The finding of anatomic alterations in the myenteric plexus would prove of value, that would practically constitute direct proof that the theories of Keith, regarding the nodal system, possessed a sound basis. This more recent knowledge of the stomach and duodenum should be taken into consideration in the study of the causation of acute dilatation of the stomach.

PYLORIC STENOSIS IN INFANCY *

BY FRANCIS OLCOTT ALLEN, JR., M.D.
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SOME time ago I reported two cases of pyloric stenosis in infants before this academy. Since then I have operated upon seven additional cases, making nine in all. This is a sufficient number to arouse one's interest in this curious pathological condition and to justify some tentative conclusions in regard to it. The subject is receiving increasing attention in the literature, and a number of valuable reports have appeared, the latest by Green and Sidbury, in the current number of *Surgery, Gynecology and Obstetrics*, discussing in considerable detail our meagre knowledge of it.

It is generally assumed that the pyloric ring is congenitally abnormal, but no explanation is forthcoming as to its true etiology. It must also be assumed that the hypertrophied muscle is thrown into spasm by unknown factors. Otherwise it is difficult to explain the frequent remission of symptoms and the occasional recovery of a patient without operation. We have not even an assumption to explain the overwhelming preponderance of the disease in boys. Girls seem to be almost exempt. All of my cases but one were boys. Like intussusception, it occurs most frequently in breast-fed infants.

The babies are usually healthy at birth, well nourished, and well formed, and make a good start. Then in a varying number of days or weeks they begin to do badly, vomit after feeding and fail to gain. The doctor in charge is driven to change the food, and for a time they again do well. Then the symptoms return and the food is changed again. This may go on for several weeks, but, as a rule, there is a progressive loss in weight until operation must be done. Many cases have some fecal evacuations, showing that the pylorus is not entirely closed, some have no stools for days at a time. The vomiting is not the regurgitant type, so common when an infant's stomach is overfilled, but is propulsive and copious.

A few quotations from my notes will illustrate the histories of these babies.

(Six weeks old.) "Baby weighed over 10 pounds at birth and did fairly well for two or three weeks, though vomiting more than normal. Then began to vomit almost everything. Weaned and various feedings given. No stools for two weeks."

(Seven weeks old.) "Has not done well since birth. Insufficient breast milk. On various mixtures. Seven and one-half at birth—reached 8.2, now 7.1. Vomiting at times. Has stools."

* Read before Philadelphia Academy of Surgery, February 13, 1919.

Ten days later.—“Wet nurse has been tried, but baby has lost weight again, vomiting. Weighs but little over 6 pounds.”

(Six weeks old.) “This was a thirteen pound baby, now weighing 5 pounds 12 ounces. Vomiting almost everything though has some stools. Emaciated, has purpuric eruption.”

(Five weeks old.) “Under observation several days. Seems to improve some days, but on the whole does not gain. Weighed 6.9 at birth.”

(Two months old.) “Vomiting began when about one month old. Has lost weight, but is not emaciated.”

(Two months old.) “Breast fed at first, then various mixtures. Frequent vomiting since about second week. Seven and three-quarter pounds at birth, now 5 pounds. Looks badly.”

Histories such as these are presumptive evidence that the pylorus is not normally patent, and in themselves would justify laparotomy. Fortunately, the diagnosis is always corroborated by the physical examination. Sooner or later gastric peristalsis becomes visible. It is best seen when the baby is taking a feeding or soon afterward. In its struggle against the obstruction, the stomach becomes distended, filling the upper abdomen, and the peristaltic waves can be seen through the thin abdominal wall passing from the left costal margin to the right. Frequently, but not always, the tumor can be felt. Its position varies. It is to be looked for on the right side between the umbilicus and the ribs. In one of my cases it was found at operation deep down under the liver; in another the distention of the stomach had carried it into the right kidney pouch. In neither of these cases was it palpable before operation.

Operation should be done as soon as the diagnosis is fairly certain. The diagnosis is made by the pediatricist, and I have never seen a case until the symptoms were fairly characteristic.

In my first case, in December, 1916, I did a gastro-enterostomy. In the others I have split the tumor longitudinally down to the mucous membrane, as suggested by Rammstedt in 1913. This operation requires care to avoid opening the duodenum, for the apex of the tumor bulges into the duodenum, and in trying to make the division of the tumor thorough enough to relieve the obstruction, it is easy to perforate the duodenal mucous membrane. I made this mistake once. I put in two fine catgut sutures and no trouble resulted. This operation requires care, also, to avoid hemorrhage. The tiny vessels come from the inferior aspect of the pylorus and I have found that the nearer the superior aspect of the pylorus the incision is made, the less the bleeding. In my first operation of this kind I made the incision on the lateral aspect of the pylorus, the easiest place, and the baby died a few hours later with its abdomen full of blood. It is almost impossible to catch and tie the vessels, so that any manœuvre to avoid them is worth while. In the last two or three cases I have operated from the left side of the patient, in

order to hold the pylorus more easily in my left hand, and make an incision in its superior aspect with my right. This is a decided gain in convenience.

In spite of these dangers in the operation, perforation and hemorrhage, the procedure is so simple, and can be done so rapidly that it is likely to supplant gastro-enterostomy. In fact, judging from the reports I have seen in the last year or two, it seems to have done so already.

Of my 8 Rammstedt operations, 2 died, a mortality of 25 per cent. Downs reported 35, with 23 per cent.; Gallie and Robertson 16, with 31 per cent.; Green and Sidbury 5, without a death. Scudder, Stillman, and Richter did 36 gastro-enterostomies with 13 per cent. mortality, a remarkably good record. My gastro-enterostomy did pretty well for a week, then died unexpectedly on the eighth day, from some undiscovered cause. My first death with the Rammstedt was from hemorrhage, as already described. The second death was my seventh case, a girl baby two months old, who had been vomiting since the second week. The condition was not recognized by the family physician and she was in poor condition when a pediatricist was called in and made the diagnosis.

I found a rather large hard nodular tumor, split it, and closed the abdomen. The baby did very well until the afternoon of the third day, when the respirations became weak, of the Cheyne-Stokes type, and death ensued quickly. The pulse remained good after the respirations began to fail. I do not know how to explain such a death. It was similar to the death of the gastro-enterostomy case. Enlarged thymus, acidosis, and other vague causes have been discussed.

In addition to these cases of pyloric stenosis due to tumor, I want to report one case of a different form.

A boy baby seemed normal after birth and did well for a time, then began to vomit and lose weight, and finally gastric peristalsis became visible. A diagnosis of stenosis was made by the family physician and consulting pediatricist, and I concurred.

I operated when the baby was three months old. Instead of the usual tumor, I found a distinct plication at the pylorus, the duodenum bent forward and adherent to the stomach for a distance of almost a quarter of an inch. The area was hyperæmic and there were definite cobweb adhesions. I divided the adhesions with scissors, and straightened out the pylorus. It seemed patulous and I did nothing more but close the abdomen. The baby did not do very well for the first week, and the wound broke open. I closed it under an anæsthetic and inspected the pylorus, finding it apparently patulous and normal. Since then the child has done well.

CHOLECYSTITIS FOLLOWING TYPHOID FEVER IN CHILDHOOD*

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SEQUELÆ of typhoid fever in childhood are not as common as in adult life. However, they are to be promptly recognized and combated when they do occur. This applies with particular emphasis in abdominal crises, that appear so suddenly, and are so rapid in their course.

The most frequent abdominal sequelæ to typhoid in childhood are perforation, hemorrhage and appendicitis, but the younger the child the less frequent is their occurrence. One of the most unusual conditions that would simulate them is cholecystitis.

Curiously enough, despite the fact that the gall-bladder harbors the *Bacillus typhosis* in large numbers after an attack of typhoid fever, cholecystitis is unusually an early sequel. It seems that the organism must be especially virulent, the individual lacking in resistance, and drainage poor, to set up an inflammation in the gall-bladder. When local infection does occur, however, it usually proceeds rapidly and an early perforation ensues. Diagnosis is usually made after perforation has taken place.

Keen's table,¹ added to by Erdmann,² contains adult cases chiefly, but Keen's nine cases under fifteen years of age, noted in the original table, have not been revised. Eight of these died, one recovering following an operation. All had perforations. The recovery noted was a case of Alexieff's,³ occurring in a five-year-old girl. The patient was doing nicely after her fifth or sixth week, when she had an attack of pain, rise in temperature, and was delirious. She was operated upon two days after the perforation occurred, and drained. Seven weeks later she had a recurrence and finally recovered.

The first evidence of abdominal pathology as a sequel to typhoid fever is pain. Pain should bring to mind at once the following: Distended bladder, diarrhœa, fecal impaction, constipation, intestinal obstruction, intestinal perforation, hemorrhage, appendicitis, iliac phlebitis, peritonitis, cholecystitis and pneumonia with pleurisy. An immediate examination will reveal other signs or symptoms that will point the way to a definite conclusion.

The localization of pain, if possible, in the upper right quadrant, radiating through to the back, tenderness and perhaps a palpably distended gall-bladder point to upper abdominal disease. Pneumonia should be carefully excluded even in the presence of very marked abdominal signs. Vomiting occurs, and the pulse rate goes up. Leucocytosis is present, 12,000 to 18,000, but may go well into the twenty thousands. The picture

* Read before the Philadelphia Academy of Surgery, February 13, 1919.

is one of profound shock, and closely resembles obstruction, perforation, or a high ruptured appendix. Time will not always permit an exact diagnosis, nor should a prolonged effort be made to differentiate the type of abdominal catastrophe, for delay will militate against the patient's chance of recovery. Keen and Erdmann show that no cases recover without operation, and four of seven that were operated did recover. All had perforations. The statistics just quoted includes the nine children previously mentioned, and aggregates thirty-four cases. The case to be presented resembles Alexieef's closely in its inception and early course, but there the similarity ceases, except that both recovered.

H. S., aged five years, was admitted to the Children's Hospital of the Mary J. Drexel Home, September 10, 1917, with her two little sisters, aged four and two years and eight months, respectively. The three had typhoid fever, as did their father and mother. The mother was also pregnant and aborted during her illness. H. had a fever for about three days, but had been ailing for about ten days.

She had nose bleed, headache and indefinite abdominal pains. There was no vomiting. She was constipated. An enlarged spleen was manifest in a few days, and rose spots also appeared. Heart and lungs were negative for any pathology, as were the extremities. Leucocyte count was 8800, and she had two positive Widal's following a negative. The temperature on admission was 103.8° F. and went to 105° F. It stayed within this range for eight days, and then came down gradually, striking normal in six days. No untoward symptoms marred her apparent rapid recovery and gain in strength from the fourth of October until the twenty-second.

On the morning of October 22, H. vomited and complained of abdominal pain. The pain was generalized. She was given an enema with good result. Lavage did not give relief. The child was shocked, abdomen rigid and tender, the thighs flexed upon the abdomen. There was no distention and feeble peristalsis was present. The temperature was subnormal. Two hours after the first pain she was operated upon. Ether was given and an incision made through the right rectus muscle. A considerable quantity of serous fluid escaped from the peritoneal cavity.

When the gall-bladder was exposed it was markedly congested, slightly distended and had a dark area along the under surface of the fundus. There was no perforation. The gall-bladder was aspirated and a thick, dark, viscid, purulo-sanguinous fluid was removed. Moist pads were used to wall off the gall-bladder. The contents upon laboratory examination showed no typhoid agglutination, the Hay bacillus being found in the culture. The gall-bladder was drained with iodoform gauze. A piece of plain gauze was placed beneath and under the gall-bladder for drainage, and a fenestrated rubber tube was placed in the pelvis. The deeper layers of the abdominal wall were sutured with chromic catgut, silkworm gut in the skin.

The gauze was removed in five days, a small strip of plain gauze being replaced in the gall-bladder. A biliary fistula developed, which was subsequently closed and the child made an uneventful recovery.

Alexieef's case and this one both began with pain in the abdomen, in the course of their fifth or sixth week of typhoid fever. Both had similar symptoms, but his case went on with fever, chills and delirium, finally getting out of bed with consequent collapse. Operation after perforation did save the child despite a recurrence. My case was operated upon promptly and had no recurrence. While a secondary operation for the fistula was performed, it was not a dangerous procedure and the child did not have as rough a road to ultimate recovery as Alexieef's patient.

This comparative picture should show the advantage of careful attention to pain as an indicator of impending abdominal disaster. It should demonstrate the vital necessity for early surgery in an acute abdominal crisis.

Finally, while sequelæ are less common after child typhoid, when they do occur, they are more fulminating in their character, and always demand immediate attention.

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PRIMARY LYMPHOSARCOMA OF THE INTESTINES*

WITH REPORT OF TWO CASES

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SARCOMA may affect any portion of the intestinal tract. The combined reports of cases in the literature bearing on the subject are not so numerous as one would suppose.

In the report of the following two cases, one affected the ileum, the other affected the ascending colon. According to Forman,¹ "The order of frequency of the sites involved is ileum, cæcum, jejunum, appendix, transverse colon, sigmoid, duodenum, and descending colon. The frequency of sarcoma of the small intestine in the male compared with that of a female is, in the cases so far recorded, about 2 to 1. In the large intestine, according to Jopson and White, the frequency of incidence is nearly equal in the two sexes. According to Speese, the fourth, third, fifth, and second decades is the order of frequency of the ages afflicted with sarcoma of the small intestines. According to the reported cases the first decade has furnished the largest number of cases and the fourth decade stands next in the order of frequency for this site. As to whether syphilis bears an etiologic relationship to the development of sarcomata, there are all sorts of opinions from Schmidt, who remarks of sarcoma that luetic antecedents are not common, to von Esmarch, who states that in his clinic more than one-half of his sarcoma patients have been luetics. Kasemyer found in 284 cases of intussusception that a sarcoma had been the cause in 26 instances. Of the 74 cases of sarcoma of the small intestine collected by Speese, for which resection of the bowel was performed, 14 were also cases of intussusception.

"Sarcoma is even more infrequent in the large than in the small intestine. It is understood that the rectum is not included in this discussion. According to the tabulation of Jopson and White and Libman, the proportion between sarcoma of the small and large intestine is about two to one."

Bull² says, "Sarcoma of the intestine is rarer than carcinoma. The relation of these two tumors is about as 1 to 20. Sarcoma may involve either the small intestine or the large intestine or rectum, while carcinoma is far more frequently found in the large intestine and rectum. Krugerz Boas, who collected reports of 37 cases of sarcoma of the intestine, found the small intestine involved 16 times, the ileocæcum once, the cæcum twice, the vermiform appendix once, the transverse colon once, both the small and

* Read before the Academy of Medicine of Toledo and Lucas Co., Ohio, April 18, 1919.

large intestine once, and the rectum 16 times. Smoler reckons one case of sarcoma of the small intestine for every thousand autopsies.

"Sarcoma of the intestine may occur at any age, but most frequently between the thirtieth and fortieth years. Most of the cases reported have been in females. In Siegel's collection of 34 cases 19 of the tumors were round-cell and 5 spindle-cell. The other tumors were alveolar or melanotic cystosarcoma, lymphosarcoma, myxosarcoma, and endothelioma. Tuberculosis and sarcoma may coexist. Usually an intestinal sarcoma begins in the submucosa.

"Sarcoma of the intestine may reach a considerable size. In counter-distinction to carcinoma, it involves a considerable extent of the bowel and is much more likely to grow into the neighboring organs, especially the mesentery and omentum. Hence it is not always possible to say in which organ it began. It also sets up metastases in the liver, kidney, spleen, and retroperitoneal glands. In another respect sarcoma of the intestine differs from carcinoma; several writers have called attention to the absence of stenosis with sarcoma, and indeed, the lumen of the affected bowel may be considerably increased. There are, however, instances in which sarcoma has produced stenosis of a high degree. Siegel asserts that symptoms of stenosis occur in about one-half of the cases."

Keen³ in considering sarcoma of the small intestines says: "No case of this kind was observed in the Berlin Pathological Institute from 1859 to 1875. Smoler studied 13 cases occurring at Prague within fifteen years among 13,036 autopsies. Twelve cases, according to Nothnagel, occurred in Vienna between 1882 and 1893. The small intestine is most frequently the seat of these lymphosarcomata. In the large intestine they are much rarer, except in the rectum, where they occur as frequently as in the small intestine. Krueger gives the following statistics of 37 cases: The small intestine, 16; ileum and cæcum, 1; small intestine and colon, 1; rectum, 16. Baltzer states that 57.8 per cent. of the cases occur in the fourth decennium. Libman found among 42 cases, 15 involving the duodenum, 18 the jejunum and ileum, 14 the ileum, and 3 the entire intestinal tract.

"All microscopic varieties of sarcoma are observed in the intestine. Usually the neoplasm involves only the mucosa and the muscularis, the serosa being almost or quite free. In quite isolated cases the neoplasm took its origin in the serosa, and extended from there to the inner layers, the lymphosarcoma, which form the largest group, begin commonly in the submucous lymph-glands and grow along the axis of the bowel. The muscularis is early involved and paralyzed, permitting the fæces and gas to dilate the bowel. This intestinal dilatation is an especial, although not constant attendant phenomenon of lymphosarcoma of the intestine.

"The tumor may compress the vena cava, the biliary passages, the ductus pancreaticus, or the ureters. Ulceration is very frequent, and may lead to perforation either through an intestinal loop or into the abdominal



FIG. 1.—Tumor much contracted by preserving fluid. Now measures $17\frac{1}{2} \times 17\frac{1}{2} \times 12\frac{1}{2}$ cm. *a*, cæcum; *b*, distal end of ileum; *c*, cut surface of tumor; *d*, the opening of the cut transverse.



FIG. 2.—Posterior surface. *a*, retracted opening of transverse colon; *b*, cæcum.



FIG. 3.—Tumor cut open. Note central ulceration and necrosis of mass with hemorrhagic infarcts.

PRIMARY LYMPHOSARCOMA OF THE INTESTINES

cavity. Metastases may also take place in various parts of the body." Jopson and White⁴ found 22 cases of sarcoma of large intestine. In 14 only was the growth confined to large intestine primarily. Three of these cases were confined to cæcum and ascending colon. Corner and Fairbanks⁵ collected 175 cases of sarcoma of the alimentary tract: œsophagus, 14; stomach, 58; small intestine, 65; ileocæcal, 20; colon, 11; rectum, 7. Sarcoma⁶ occurring in stomach according to recent statistics of Wild, Curlt, Tilger, Donath, Haberkant, Yates, and Lexer, in but 1 per cent., or at the most, 2 per cent. of cases, is an unusual condition. Hesse reports a case which has the added feature that the patient was in good health seven and one-half years following resection of about two-thirds of the stomach. Gosset, in reporting his case, found in the literature 171 cases, 21 of which had been overlooked by Zesas, or had been published since his monograph appeared. Gosset's patient, on whom a gastrectomy was done, was observed until a month and a half after operation, and at that time was doing well.

Metastasis is not as frequently seen as in carcinoma, but when it does occur, secondary growths are seen in the liver and in the neighboring glands, the mesenteric glands, in the kidneys, ovaries, lungs, and skin. The diagnosis is rarely made clinically, as the condition is so infrequent that one does not bear it in mind. There are no symptoms by which the nature of the tumor can be determined before autopsy *in vivo* or *post-mortem*.

Goto has made a complete literary review of the subject of ileocæcal sarcoma, and draws the following conclusions: It is more common in the males after fifty years of age. From the pathological standpoint it is expressed as circumscribed tumors which frequently lead to stenosis. Symptomatically there is rapid emaciation, a tumor which is readily movable on palpation, and which grows very rapidly, with signs of stenosis. It is very difficult to make a diagnosis between sarcoma and carcinoma. Prognostically, sarcoma of this region is much more favorable than in other localities. Farr⁷ reports a successful case of resection of cæcum for sarcoma involving the ascending colon, and says he could find but 3 cases involving the cæcum and ascending colon reported up to the time of the report of his case. Hitzrot⁸ reports a successful resection of the jejunum for three tumor masses near the portion of the small intestine occurring in that portion of the jejunum about 20 inches from the ligament of Trietz. Gerster⁹ reports two cases of sarcoma of the intestinal tract. One involving the large portion of the duodenum about as large as a small spanish olive. The patient died from severe hemorrhages. Second case, the sarcoma as big as a hen's egg, occupying the jejunum 7 or 8 inches from the ligament of Trietz. It had caused an intussusception involving 5 or 6 inches of the gut. Intestine was resected, the patient made a good recovery. Pathological diagnosis was lymphosarcoma.

CASE I.—J. B., American, aged sixty-one, male, laborer, addicted to daily eating of white sand, with history of rapid emaciation and beginning cachexia, presented on examination a firm mass in left umbilical region.

Operation March 22, 1915, revealed tumor of ileum, the size of egg, encroaching upon the mesentery with much thickening of mesenteric fold and induration of a large section of ileum.

Three feet of the ileum with corresponding mesentery were resected, followed by an entero-colostomy: the proximal end of the ileum was anastomosed to the ascending colon. Drainage was instituted. Case made an uneventful recovery. Discharged from hospital April 17, 1915.

Pathological section by Doctor Hindman shows lymphosarcoma of ileum.

Death ensued ten months later from acute hemorrhage of bowel associated with severe pain and tenesmus.

CASE II.—Mrs. H., German, aged sixty-seven, usual weight 180, strong and muscular, present weight 140, weak, cachectic in appearance, gave the following history: Father died of apoplexy at 63; mother, 83, liver trouble; one brother 48 died of cancer of rectum.

Personal History.—Had measles. Menstruated at thirteen, normal. Married at twenty. Six pregnancies, normal deliveries, nursed each one to one and one-half years. Appetite always good, a mixed eater, food always cooked but great fondness for raw apples; never constipated. Has had bad teeth with pyorrhœa for years. Had rheumatic fever often for past fifteen years. Thirty-five years ago had gastric disturbance with vomiting, and repeated often to menopause at fifty-one. Four years ago gastric attack with jaundice.

Present illness began October 20, 1918. Some pain in right abdominal region and shortly after noticed a lump. Never noticed blood or mucus in stools. Physical examination shows emaciation with cachexia, pyorrhœa, myocarditis with intermissions of pulse. Blood-pressure, S 155, D 85. Abdominal palpation revealed a tumor, freely movable, not sensitive to pressure in upper right quadrant. The balance of organs were normal. Examination of stools demonstrated occult blood and bloody mucus. Urine negative, excess of indican.

X-ray shows stomach fills normally, is in good position and shows normal peristalsis. A large mass can be felt, apparently in the colon just above the cæcum.

Six-hour Finding.—Stomach empty, bismuth in colon to splenic flexure, filling defect just above cæcum. A slight amount of the barium meal still in the terminal ileum.

Ten-hour Finding.—Ileum empty, barium meal in colon to splenic flexure.

Twenty-six-hour Finding.—Bowel nearly empty, traces only of the barium meal left. A trace in the mass above the cæcum.

PRIMARY LYMPHOSARCOMA OF THE INTESTINES

Under gas-oxygen anaesthesia operation December 12, 1918, revealed a non-adherent tumor of ascending colon about two inches below the hepatic flexure the size of a small orange. A contracted gall-bladder filled with stones was also present. Owing to the severity of symptoms a two-step operation was deemed advisable. The ascending colon was excluded and the ileum anastomosed to the left transverse colon. She left the hospital after the fourth week.

There was an interim of three months before her second operation, an interim of decided improvement and a later recurrence of pain and ill feeling that forced her to seek further surgical interference. On opening the abdomen, the tumor had penetrated the wall of the colon and through the transversalis and oblique muscles, the colon firmly adherent to abdominal wall and under surface of liver. The affected portions were removed *en masse*, as well as perirenal fat, superficial lymphatics of kidney, gall-bladder and mesenteric glands. Bleeding somewhat profuse. The omentum was utilized in the exclusion of the large open abdominal space. Both the gall-bladder and kidney area were drained, tubes removed on the seventh and fourteenth day, respectively. Left hospital fourth week, wounds closed. Up to present time she reports herself well.

Several sections of the tumor made by Doctor Hindman demonstrate a lymphosarcoma of the colon.

The post-operative mortality of these cases is high, death usually ensues from peritonitis.

Both of the reported cases were drained and convalescence from the operation was uneventful.

From the review of fatal case reports and in the light of my experience, I feel constrained to advocate drainage in all.

Stenosis of the bowel was not present in first case. In case II X-ray findings and first operation showed a patent lumen of colon, but with the lapse of time occlusion developed to practically complete obstruction.

The post-operative prognosis of these cases varies. From a perusal of case reports death may result from rapid recurrence or the patient is living and well from periods of one to five years. The fatality of lymphosarcomas in other regions of the body and their tendency to recur are amenable to radiation. If radium exerts a beneficent influence in such regions, it should be used as a post-operative agent in all lymphosarcomas involving the intestinal tract. Bloodgood¹⁰ says: "The one lesion of which, as far as I know, surgery has never accomplished a cure, is lymphosarcoma of the lymph-glands, and apparently radium has done so. Therefore, as soon as this diagnosis is suggested and established, radiation should be given, and continued at intervals, to the entire lymphatic-gland system."

Case II, after short circuiting the colon, leads one to wonder why in such a brief time there was such a rapidity of growth and infiltration of

surrounding structures with extensive peritoneal adhesions. Do the enzymes have a restraining influence on these growths, or do the enzymes misdirected in their function, or the absence of them in the functionless loop, accelerate the growths? These are questions that are open for investigation either to refute or confirm.

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"THE GUILLOTINE AMPUTATION" *

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THE term "guillotine" as applied to amputations is perhaps not as suitable or as descriptive of the operation that is really done, as the term "flapless operation," but priority counts for much in medicine and surgery and the word will, no doubt, continue in use.

The guillotine amputation is, as far as modern surgery is concerned, a product of the World War. The method was used and advocated by Fitzmaurice-Kelly in 1915 as a life-saving measure for certain types of severe infections following war wounds. He recommended its use in cases of gas gangrene, compound comminuted fractures in which amputation was indicated and in certain cases with multiple wounds. One statement of his in regard to the operation is, "that it seems advisable to make it clear that the method is not a routine one, but is designed to meet new difficulties and dangers, and is used in special cases for quite definite reasons." Its advantages are enumerated by him as life-saving, saving of length of limb, lessening the risk of hemorrhage, arresting the spread of infection, and as being possible when no other method is possible. To these may be added the advantage of shortening the time of the operation and anæsthetic, thereby reducing shock. It is to be emphasized that the operation is done as a life-saving procedure and carries with it the probability of a future operation.

The technic of the guillotine operation as described by Fitzmaurice-Kelly was not a true guillotine in the sense that the extremity was cut squarely off as might have been done with the historic guillotine blade. The skin was divided in a circular fashion, permitted to retract, as it will always do to a certain extent, and the muscles and bone were divided in the plane of the retracted skin. So many modifications of this procedure have been used, depending usually upon the available tissue, that it is probably wiser to include under the term guillotine all flapless amputations.

It has been urged by some that flap operations should be done instead of the guillotine and drainage facilitated by packing the flaps apart or stitching them back until infection subsides. In order to make flaps above the diseased part it is necessary to remove more bone than with the guillotine technic. By making flaps the drainage is apt to be hampered, the flaps may slough and if they do not slough may become distorted and produce a misshapen and undesirable stump requiring further operation.

* From the Orthopædic Service of United States General Hospital No. 26, Fort Des Moines, Iowa.

If a guillotine is done as low on the limb as the infection will permit and at a later date a reamputation done, if necessary, the chances for sound healing and a good stump with minimum loss of bone are decidedly better than with original higher section of bone with skin flap. The so-called oblique guillotine is a splendid operation when the tissues will permit of its use. This is especially true in thigh amputations when the skin is left longer anteriorly than posteriorly. Quite a large percentage of oblique guillotine amputations of the lower thigh heal and make satisfactory stumps without further operation, and if operation is advisable a good end-covering of the stump with anterior flap can be made with little or no sacrifice of bone.

The guillotine operation will doubtless be used in selected cases in civil practice. Many surgeons can look back upon cases of serious infection of extremities in which amputation was not permitted until all hope for life had vanished without it, and when the amputation was done the patient died because of continued progress of the infection. In such cases and in the presence of gas infection the guillotine should be the operation of choice in the future.

We have been most interested in the guillotine operation as it is seen in the reconstruction hospital. Many of the overseas amputated admitted to the hospitals of this country have unhealed flapless stumps three to five months after the original operation. Of 335 patients with amputations from overseas admitted to the U. S. General Hospital No. 26, Fort Des Moines, Iowa, 199 had flapless operations; 141 of this number were unhealed upon arrival; 133 of the guillotines have been operated upon or will require operation. The accompanying table gives the statistics more in detail.

STATISTICAL TABLE OF GUILLOTINE AMPUTATIONS

Total number of overseas cases amputated	335
Total number of guillotine amputations	199 or 59 per cent.
Number of healed guillotines on admission	58 or 30 per cent.
Number of unhealed guillotines on admission	141 or 70 per cent.
Guillotined legs: Healed	7
Unhealed	31
Guillotined thighs: Healed	22
Unhealed	69
Guillotined arms: Healed	20
Unhealed	25
Guillotined forearms: Healed	9
Unhealed	13
Guillotined feet: Healed	0
Unhealed	3
Number of guillotines operated or requiring operation	133 or 66 per cent.
Legs requiring operation	30
Thighs requiring operation	76
Arms requiring operation	17
Forearms requiring operation	8
Feet requiring operation	2



FIG. 1.—Typical guillotine of upper thigh. Unhealed after six months.



FIG. 2.—Same as Fig. 1; four weeks after reamputation.

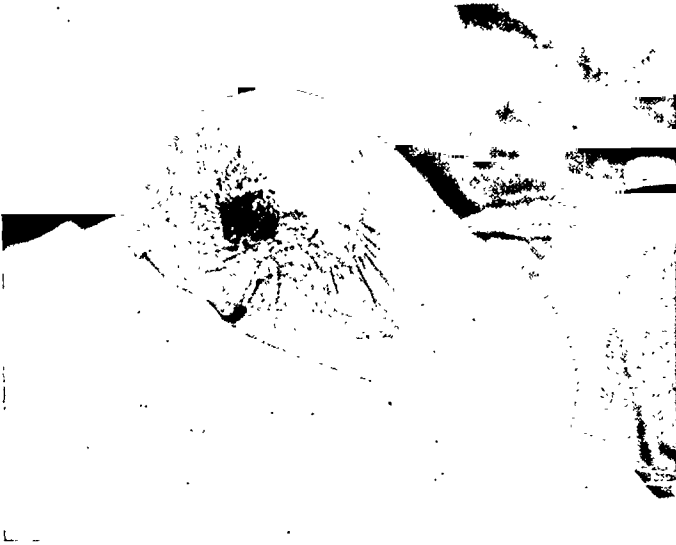


FIG. 3.—Oblique guillotine of lower third of thigh. Healed and, with trial fitting of artificial leg, again ulcerated.



FIG. 4.—Same as Fig. 3, four weeks after reamputation. Shows anterior flap covering end of bone. Patient discharged with good stump.

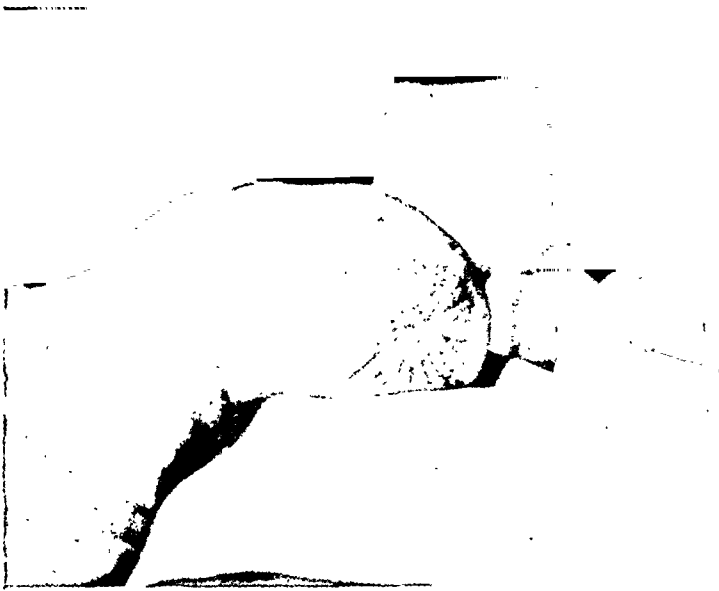


FIG. 5.—Healed guillotine of upper arm. Satisfactory stump. Wears artificial arm with comfort.



FIG. 6.—Healed oblique guillotine of lower third of thigh. Scar movable over bone. Discharged with satisfactory leg fittings.



FIG. 7.—Unhealed oblique guillotine of thigh with protruding bone spur.

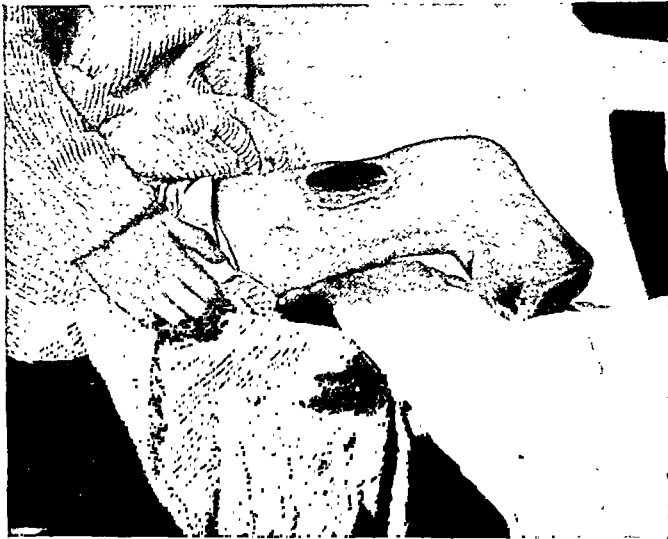


FIG. 8.—Guillotine of leg with contracture at knee.

"THE GUILLOTINE AMPUTATION"

The operations required have been reamputations, plastics on the soft tissues, excision of bone spurs and sequestrectomies. The percentage of tender stumps due to neuromata has been very small. To date we have removed two tender bulbous nerve ends.

Reamputation is indicated in all cases where it is evident that sound healing will not take place over the protruding bone, in healed cases with large poorly nourished scars over prominent bone ends and when the site of the former amputation is undesirable for fitting.

Plastic operations are done for deep adherent irregular scars that are tender, prone to ulcerate or produce an eczematous condition of the surrounding skin. At times it is difficult to determine whether reamputation or a plastic operation is necessary. Trial fittings aid in making a decision for or against operation. It has been learned by experience that a poor appearing stump often makes a good functional stump.

Bone spurs have been found in quite a large percentage of cases following the guillotine type of operation. Usually these spurs extend toward the granulating surface, along sinus tracts or along fascial planes between muscles. They may or may not cause trouble, depending upon their size and location. Spurs are not to be removed because of the X-ray appearance alone. When in doubt, here again artificial limb fitting is tried, which will usually decide the question of operation.

Sequestra are not infrequent in guillotined stumps. Many of them are of the ring type. The end of the sectioned bone becomes entirely separated from the shaft in the shape of an irregular ring which is usually imbedded in or completely surrounded by an involucrum. The frequency of ring sequestra may be partially due to the denuding of the end of the bone of periosteum, the aperiosteal method of Bunge.

The time of secondary operation on guillotined or infected stumps cannot be too carefully considered. To recognize this time is the deciding point between success and failure. It would be ideal to wait from three to six months after sound healing before operation, but this is hardly practicable for returned overseas soldiers in a military hospital. And it has been found that this long wait is not necessary for success. It is very necessary, however, to wait until all œdema has disappeared from the stump tissues. Early reamputation has been recommended by some writers, including Chapple² and Neve³ of England, but we are convinced that the teachings of Huggins⁴ is correct in that there should be no œdema present when secondary operation is attempted. By œdema not alone is meant the ordinary swelling that puts on pressure, but also the deep firm induration that exists around the end of the bone. When this condition exists there is certain to be more or less active infection harbored in the deep scar tissue, bone granulations and lymph spaces. When the œdema and induration of the soft parts have completely disappeared the stump may be operated upon with success regardless of the presence of unhealed areas. The length of time for tissues to reach this stage varies

greatly. Many patients have returned from France three or four months after amputation with marked œdema still present in the stump. The long duration of this condition may be accounted for partially by the frequent transferring of patients from one hospital to another that has been necessary to return them to the States. With proper treatment, including rest in bed and often warm, moist, antiseptic dressings, the active infection and œdema will usually disappear in from two to four weeks after the patient has reached the last hospital. The disappearance of the deep œdema is evidenced by the ability to pick up the skin and the soft tissues of the stump between the thumb and fingers. The skin is loose and can be moved about over the muscle beneath. The most important single treatment that can be used is traction. Traction promotes healing, lessens the formation of wide areas of scar tissue and conserves length of bone. As soon as a guillotine amputation is done traction should be applied to the retracting skin by means of adhesive strapping and weight and pulley, the Thomas splint or some modification thereof. This is most necessary in thigh stumps. Traction may, in some cases, be continued over a period of several weeks with marked benefit.

Aside from the danger of infections following too early operation there is a mechanical factor to be considered. In an œdematous indurated stump it is often difficult to shape and make a satisfactory closure with hard thickened skin flaps. If healing does take place under such conditions the flaps are more apt to become distorted with extensive puckered scars.

All healed cases have received forty-eight hours' preparation of the part to be operated and unhealed cases are prepared twenty-four hours prior to operation. In addition to this at the operating table the field of operation is again carefully cleansed with benzine followed by Harrington's solution and alcohol. In the unhealed cases, before the incision is made, the area to be removed is carefully painted with full strength phenol and covered with gauze to prevent wound soiling. In no case has it been necessary to remove more than two and one-half cm. of bone to effect a flap closure in the guillotined stumps. Usually the removal of one or two cm. of bone has been sufficient. It is often necessary, especially in the upper thigh guillotines, to raise anterior and posterior flaps for a distance of three to eight cm. to permit closure over the end of the bone without tension. When bone spurs are present they are usually removed when reamputating but needless operating is not done and good bone never sacrificed to remove small and what seem to be harmless spurs. It may be of some interest to note that the femoral artery has never been opened in reamputations upon thigh stumps. Bleeding is always very free in these healing or healed stumps, but the larger vessels are seldom encountered.

In sequestrectomies and the more serious types of guillotined thigh stumps the Carrel-Dakin treatment is used and has given good results.

"THE GUILLOTINE AMPUTATION"

In a great majority of the cases sound healing will take place with only rubber-tube drainage. In all cases where blood or serum is apt to collect beneath flaps drainage is used.

Judging from knowledge we have received we have nothing but praise for the work of the surgeons overseas in handling the amputated. For the most part patients have received good and proper amputations and postamputation treatment. There are, without question, cases that would have healed with flap operations and primary or secondary suture when the guillotine was used, but from the histories we are able to obtain such cases are very much in the minority, and at the time the amputations were done were probably doubtful or potentially infected cases.

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TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

Stated Meeting, held February 12, 1919

The President, DR. CHARLES H. PECK, in the Chair

CARCINOMA OF THE STOMACH—POLYA-BALFOUR OPERATION

DR. JOHN F. ERDMANN presented five cases of resection of the stomach for carcinoma, by the Polya-Balfour method; these were five out of thirteen which he had done in the past five months. He showed X-rays of the cases and an X-ray of one of the post-operative patients, showing the current of barium very beautifully. The youngest of these patients was twenty-seven and the oldest was sixty-nine.

DR. CHARLES N. DOWD presented a case similar to the ones presented by Doctor Erdmann. A year ago the patient came to the hospital; she had been suffering for many months, was continually vomiting, emaciated and only weighed one hundred and ten pounds, a loss of thirty-seven pounds. On palpation a mass was felt and the Polya operation was done. No difficulty was experienced in bringing the jejunum through the transverse mesocolon, and one-half of the stomach was resected. She made a quick recovery and at the present time is well and weighs one hundred and twenty-seven pounds.

DOCTOR DOWD asked if there was any information as to the condition of the proximal loop in the anterior Polya procedure.

DR. HERMANN FISCHER said that some time ago he had the opportunity to present one of his patients upon whom this operation had been performed. He was very much pleased with the result of it. All five patients upon whom he operated stood the operation very well, although three of them had carcinoma and were not altogether good risks. The post-operative recovery was comparatively quick. The X-ray examination after the operation showed in all patients a slight delay in the evacuation of the stomach contents, probably due to a muscular weakness, caused by the operative trauma. The patients had, however, no subjective symptoms. In performing the operation he has found it practical to divide the duodenum first, after having freed the stomach from its attachments. The stomach is then pulled out of the abdomen until sufficiently exposed to attach the loop of small intestine (jejunum) at the place where the anastomosis is to take place. Two guide sutures are placed at the small and large curvature and the tumor resected. This obviates the necessity of using clamps.

RECURRENT ULCER OF THE STOMACH

DR. WILLY MEYER stated that last fall he had an opportunity to do a Polya operation and was struck by the apparent ease and beauty of the whole procedure as modified by Balfour and was delighted by the result. The patient made a good recovery and is well to-day. At first she mashed everything she ate, but lately has been partaking of food with her family. There is one point in these cases with regard to the slipping of the stomach-stump from the grasp of the clamp at the upper angle, if the resection had to be done well towards the cardia, close to the costal arch. Such slipping will not make a very great deal of trouble because the area is well padded with gauze below. Still, it is most unwelcome. To avoid slipping one will best apply an additional rectangular clamp at the lesser curvature, nearer to the cardia, or stitch and tie the stomach at the upper angle on to the clamp.

DR. GEORGE WOOLSEY said of Doctor Dowd's question in regard to what happens to the long loop, that he was going to ask Doctor Erdmann what, in his opinion, is the advantage of the Balfour modification, especially in the first case, where the carcinoma was well toward the pyloric end. He could see the advantage of it where one has to resect over one-half of the stomach, for there one has to pull up quite a loop of the jejunum through the transverse mesocolon, and he has often wondered whether there was any chance of strangulation in that passage through the transverse mesocolon. The convalescence is remarkably smooth after the Polya-Reichel operation; much smoother than after simple gastro-enterostomy.

DOCTOR ERDMANN in closing said he had not seen any untoward results from the Polya-Balfour operation, but on reading the Balfour article, one will note that the writer insists very distinctly that the proximal end is attached to the lesser curvature and the distal end attached to the greater curvature. He does not state why.

DOCTOR ERDMANN stated that he had done somewhere in the neighborhood of eighty Polya operations in the last four years and had had two deaths by the loop going up through the mesentery (this was evident by X-ray) and becoming strangulated because of the early absorption of the suture material used attaching the stomach to the hole in the transverse mesocolon. Since that accident he has used the Pagenstecher suture.

In regard to the modification question of Doctor Woolsey he said that he had never had any more trouble in doing the original Polya than with the Polya-Balfour.

RECURRENT ULCER OF THE STOMACH

DR. JOHN ROGERS presented a patient, aged twenty-six, who gave a long history of epigastric distress beginning in 1915. In August, 1917, she was operated upon in the Polyclinic Hospital for gastric ulcer and an hour-glass contraction was found. The surgeon who performed the operation told him that he excised an ulcer about one inch in diameter

from the centre of the lesser curvature, after separating from the ulcer a strip of the great omentum which indented the greater curvature, the stomach resumed its normal outline, and he therefore only closed the space left after the excision of the ulcer.

The recovery was uneventful, but the patient says the epigastric pain and distress were only partially relieved. After resuming work the symptoms increased and were accompanied by recurring attacks of vomiting.

When she came to Bellevue in January, 1919, the gastric analysis showed a total acidity of 20, and the radiograph a typical hour-glass contraction at the junction of the upper and middle thirds of the stomach. The test meal had apparently been recovered only from the upper pouch.

On January 15, 1919, the abdomen was opened through the outer border of the upper end of the left rectus. The stricture under the left costal arch could only be partially drawn into the wound. A band from the great omentum was separated from the ulcer in the concavity of the indentation on the lesser curvature, and this allowed the indentation on the greater curvature to disappear. The borders of the indentation on the lesser curvature with the ulcer at the bottom were then resected, leaving intact about one inch of the anterior and posterior surfaces of the stomach at the greater curvature. In this area along the greater curvature there was no scar tissue. After the removal of this V-shaped segment of the stomach, the borders of the wound were sutured so as to restore almost perfectly the normal contour and the abdomen was closed. In the subsequent twenty-four hours the condition was precarious, as the operation on account of the inaccessibility of the ulcer and stricture was long and difficult, but the recovery was then uneventful. A radiograph taken a month later showed that the hour-glass contraction had already partially reformed, and the patient is presented to show the apparent necessity of complete transverse resection in these cases, even though at the time of operation a part of the "hour-glass" contraction is free from cicatricial tissue. At present, however, this patient has no subjective symptoms.

CASES ILLUSTRATING THE CONSERVATIVE TREATMENT OF SARCOMA OF THE LONG BONES

DR. WILLIAM B. COLEY presented the following series of patients:

CASE I.—*Recurrent inoperable fibrosarcoma of the nasopharynx and soft palate; apparent entire disappearance under the mixed toxins of erysipelas and bacillus prodigiosus and radium.* Male, aged thirty years, who was referred to him on August 30, 1918, by Dr. W. B. Shields, of St. Louis, with the following history:

Family History.—About five years ago a fibrous mass was removed from the left nostril. The nose remained in good shape until the spring of 1918 when the patient noticed increasing obstruction in the left nostril. He paid little attention to it until the other nostril

began to be obstructed in the same manner. He then consulted a physician who operated on the left side and found a considerable growth extending back into the nasopharynx. It was found impossible to remove the entire tumor, which continued to increase rapidly in size after the operation.

Five weeks before he was referred to Doctor Coley, his physician, Doctor Shields, had begun the use of the mixed toxins of erysipelas and bacillus prodigiosus, injecting same systemically and into the tumor with some decrease in the size of the growth. The patient has lost twenty-five pounds in weight.

Physical examination at the time of his admission to the Memorial Hospital (September 3, 1918) showed both nostrils completely blocked by a tumor (making it impossible for the patient to get any air through either nostril), which, in addition, extended down behind the soft palate, pushing it forward into the cavity of the mouth. The most dependent portion extended down behind the uvula, causing great difficulty in talking or swallowing.

The toxins were continued in doses sufficient to produce a marked reaction, and radium treatment was started on September 24, 1918. Three small glass tubes containing a total of 10 mc. of radium emanations were imbedded in the tumor behind the palate. At this time the tumor in the soft palate had broken through the mucous membrane and a fungating mass the size of a hickory nut projected into the mouth. On September 27th, two tubes of 55 mc. radium emanations were placed in each nostril for two hours. On October 18th, three more tubes containing 13 mc. were imbedded, through a fine trocar, in the tumor behind the palate. In all the patient received 3256 mc. hours of radium emanations.

The tumor slowly but steadily decreased in size and by December, 1918, he was able to breathe through the right nostril, and two to three weeks later to get air through the left nostril as well. He also began to gain in weight, and up to the present time has more than regained the 25 pounds which he previously lost. By January 1, 1919, the tumor had practically disappeared, and at present there is apparently no tumor remaining in the soft palate and his nostrils are all clear.

Doctor Coley stated that it was impossible to say anything about the final prognosis, but that thus far the progress has been very satisfactory. A microscopical examination of the tumor, made in St. Louis, showed it to be fibrosarcoma.¹

CASE II.—*Central sarcoma of the radius, clinical and X-ray diagnosis, inoperable without sacrifice of the arm.* Male, thirty-nine years of age, referred to him by Dr. V. P. Gibney on April 25, 1918, with the following history: Eight years ago, bad sprain of the wrist, but apparently completely recovered. In November, 1917, or five months prior to Doctor Coley's first observation, noticed sharp pain, like the prick of a needle; two months later loss of power in hand; at the

¹ NOTE (May 20, 1919).—Shortly after leaving hospital tumor recurred and grew rapidly. It is again decreasing under treatment, but recovery is very doubtful.

same time he noticed an enlargement of the lower portion of the left wrist which increased rapidly.

Physical examination showed enlargement of the lower portion of the left forearm, extending down to the wrist. The tumor was apparently primary in the radius, involving the lower three inches. The whole wrist was markedly enlarged, the circumference being $2\frac{1}{2}$ inches greater than on the normal side, with some thickening of the ulna as well. There was a pathologic fracture of the radius and almost complete fracture of the ulna. The skin was normal and not adherent; the tumor was soft, semi-fluctuating in consistency. The clinical diagnosis of sarcoma was made and confirmed by X-ray examination. The X-ray picture showed complete destruction of the radius for more than 2 inches; the tumor had apparently broken through the outer shell of bone and extended outward, involving the soft parts which were pushed to one side. On the left side the tumor extended beyond the ulna which was apparently involved. The X-ray picture did not fully show the damage to the ulna, but the clinical examination showed almost complete pathologic fracture.

Amputation had been advised and the patient was willing to sacrifice the arm, if necessary. He was admitted to the Hospital for Ruptured and Crippled on April 25, 1918, and put upon the systemic injections of the mixed toxins of erysipelas and bacillus prodigiosus. Only one injection was made directly into the tumor, $\frac{1}{8}$ minim. This was followed by a very severe reaction, a temperature of 104° , nausea and vomiting and marked herpes of the lip. The systemic injections did not produce any marked chill or severe reaction until the dose had been increased up to 6 mm., finally increased to 12 minims. At the time the toxins were begun the measurement over the most protuberant part of the tumor, 2 inches above the lower end of the radius, was $10\frac{1}{2}$ inches; normal side, 8 inches. Doctor Coley stated that he had first intended to use both radium and the toxins in the hope of saving the limb. During the first two to three weeks of toxin treatment there was very little improvement and in the early part of June, when Doctor Coley was out of town for a week, Dr. J. P. Hogue, who was left in charge of this case, came very near amputating the arm, believing that there was little or no hope of saving it by conservative treatment. The patient was quite willing to submit to the operation.

When on Doctor Coley's return on June 10, there seemed to be appreciable improvement, he decided not to use any radium and the injections of toxins were kept up systemically, every other day, in doses sufficient to produce a temperature reaction of 102° to 104° . By the end of June the swelling had nearly subsided and by the end of July it had entirely disappeared. The arm had been kept in splints during the early part of the treatment and later, after the tumor had disappeared, was kept in plaster-Paris with the hand in an abducted position, to avoid deformity while the new bone was forming. The patient left the hospital in August, and the treat-

ment was kept up 2 or 3 times a week until the 1st of January, 1919. Frequent X-ray pictures were taken of the wrist, and these show gradual increase in new bone taking the place of the 3 inches of radius and ulna which had been completely destroyed. The patient is still wearing a short palmar splint; the new bone which has replaced the lower end of the radius is not entirely solid yet, but Doctor Coley believed that it would soon be completely restored and the arm would be quite as useful as ever. He felt some confidence in his prognosis for the reason that in two similar cases in which the tumor had disappeared under the toxins without other treatment—the diagnosis of sarcoma in both confirmed by microscopical examination—there had been complete restoration of the function of the respective limb; one of these patients was now well more than ten years and another was well three years when last observed.²

CASE III.—*Very large inoperable sarcoma of the upper portion of the femur, following a recent fracture; disappearance under combined toxins and radium treatment.* Male, thirty-six years of age, who had been entirely well up to January, 1917, when he slipped on the ice, causing a fracture of the left femur, a little below the trochanter. He was taken to St. Vincent's Hospital in Bridgeport, Conn., where he was treated by Col. Geo. W. Hawley. Doctor Coley stated that X-ray pictures had been taken at the time, but owing to Colonel Hawley's having been engaged in military service, he has been unable to see the pictures as yet, but he had seen the hospital report of the X-rays and had it confirmed personally by Colonel Hawley. The hospital report mentioned nothing more than an oblique fracture below the trochanter. If there had been a pathologic fracture due to a tumor already present, it probably would have been discovered at the time of the first X-ray picture. The patient did well for nine weeks, at the end of which time a swelling appeared at the site of the fracture, and steadily increased in size. He remained at St. Vincent's Hospital for twenty-seven weeks. The tumor steadily increased in size, and on October 3d the patient was admitted to the German Hospital, New York City, where he came under the care of Dr. Hermann Fischer. On October 20, Doctor Fischer referred the patient, as an inoperable case, to Doctor Coley's service at the Memorial Hospital. He was examined at a conference of the hospital staff, and all regarded the case as a sarcoma of the femur entirely beyond hip-joint amputation. At this time the middle upper portion of the left thigh measured 68½ cm. and the right thigh, 51 cm. Longitudinally the tumor extended for a distance of 17 cm. The mixed toxins were begun on October 30, 1917, and continued 3 or 4 times a week, alternating the systemic with local injections, and producing severe reactions. On November 5 and 6 he was treated with very large doses of radium, by means of a pack, applied at 10 cm. distance, and remaining for a total of sixty-one hours. He received a total of 40,000 mc. hour at one treatment. An

² May 2, 1919. The wrist is practically normal and patient working without any splint or support.

X-ray picture taken at the time of his admission to the Memorial Hospital showed complete destruction of the bone, involving the neck of the trochanter and upper five inches of the shaft. An X-ray picture of the chest showed "chronic diffused bronchitis both apices (cloudy plates) suggestive of tuberculosis—probably metastases from the tumor in the femur."

By December 10 there had been a decrease of 4 cm. in the circumference of the thigh. The radium was again applied on December 25, 1917. Examination on April 8, 1918, showed a still further decrease in the circumference of the thigh. The toxins were kept up without further radium treatment. On June 23d the patient was sent home to Bridgeport, Conn., to remain there during the hot weather and return in the fall. At that time his general health was good; the tumor had decreased in circumference from 68 to 60 cm., with a corresponding decrease in the vertical dimension; there was still marked mobility at the site of the fracture. The leg was put in a Thomas splint. He received no treatment during the summer.

On October 8, 1918, the patient was readmitted to the hospital, at which time his general health was good, and clinical examination showed apparently complete disappearance of the tumor. The circumference of the left leg, 33 inches, and the right, $38\frac{1}{4}$ inches, showing a shortening of $5\frac{1}{4}$ inches. The circumference five inches below the trochanter, left side, 21 inches, and the right, $23\frac{3}{4}$ inches. Circumference five inches above upper border of patella, left side, $19\frac{1}{2}$ inches; right, 20 inches. The patient had had no treatment since leaving the hospital in June. X-ray pictures taken at the time of his readmission showed apparently no tumor tissue left. The proximal portion of the femur at the site of the pathologic fracture had been drawn upwards to the region of the trochanter, and there was an attempt at union due to formation of new bone. X-ray examination of the chest was negative.

At the present time the patient is still wearing the Thomas splint adjusted by Doctor Gibney. He is in excellent health and his weight is normal.³

CASES IV AND V.—Doctor Coley also again showed two cases of extensive sarcoma of the long bones, one of the femur, involving the knee-joint, the other of the upper end of the tibia, in both of which cases amputation had been advised, but which had recovered, one under the toxins alone, the other under combined toxin and radium treatment. Both of these cases were shown before the New York Surgical Society, November 22, 1916. At that time they were using crutches. The patients are now in good health and walking without crutch or cane, one four and one-half years after treatment, the other three and one-half years after treatment. These cases were reported in full in the Transactions of the New York Surgical Society of November 22, 1916 (ANNALS OF SURGERY, March, 1917, p. 370) and the report contains a full record of the cases together with photographs and microphotographs.

³ NOTE (May 10, 1919).—Union is nearly complete and patient is getting about with a Thomas splint and high shoe. X-ray shows no trace of tumor.

SARCOMA OF THE LONG BONES

The first case was a central sarcoma of the lower end of the femur with extensive involvement of the knee-joint, in which Doctor Coley and Dr. V. P. Gibney both advised amputation, but the patient refused. This patient recovered entirely under no other treatment than the toxins, administered systemically and kept up for nearly a year. She is still wearing a brace fitted by Doctor Gibney and has about $2\frac{1}{2}$ inches shortening, due to the fact that one condyle was completely destroyed and the other was pushed to the outer side, so that the femur now rests upon the upper end of the tibia with a stiff joint.

The second case was a mixed-celled (giant and spindle) sarcoma of the upper end of the tibia with (some) involvement of the fibula. In this case Doctor Whitman had strongly advised amputation, believing that the leg would be of no use even if the disease was cured, but the patient refused. The tumor, which involved 5 inches of the upper end of the tibia and a portion of the fibula, was thoroughly curetted out under ether, the wound packed and the limb put in a plaster splint, and the toxin treatment begun. Four months later the toxins were left off for a month. The disease rapidly recurred. A second curetting was performed with immediate recurrence and the patient then put back on the toxins, this time combined with radium on two occasions; first 150 mc. radium emanations were applied and later 240 mc. for fourteen hours. The toxins were continued six months longer. The patient remains well at the present time, three and one-half years later. There has been reformation of the bone and she now has a very useful limb, walking without crutch or cane.

DR. GEORGE WOOLSEY said that cases of sarcoma cured without amputation are bright spots in surgery. Fortunately, there is a class of tumor, the central large giant-celled sarcoma of the long bones, that we can treat in this way. He related an experience he had three years ago where he curetted the lower end of the femur and had X-ray treatment applied at intervals for the next year. The patient is well to-day. In an earlier case local recurrence within a year had led to amputation. It is possible that repetition of the curetting might have been effective.

DR. WILLY MEYER mentioned a case where he had done the radical excision of the breast in a woman believed to have Paget's disease. She had been treated with chemical escharotics (the breast and nipple having been destroyed). Being the mother of five children, she, at first, never allowed radical work. About half a year after the operation she developed signs of a typical "cancer en cuirasse." He now referred the patient to the General Memorial Hospital for treatment with radium and X-ray, and to-day the disseminated cancer nodules have disappeared. He did not know whether there is any internal carcinoma developing, but she does not cough and there is no sign of recurrence. The radium and X-ray have been found to favorably influence this dreaded occurrence. Now she has developed a cancer of the other breast and will be operated on in a few days.

ABDOMINAL LIPOMATOSIS

DR. F. S. MATTHEWS presented a boy seven years of age who was admitted with a history of progressive enlargement of the abdomen. At the age of one year, he had been operated on, a large incision made, and said to have an inoperable tumor. Examination showed an emaciated boy with enormous abdomen, flat on percussion, feeling soft rather than tense, and on deep pressure giving the impression of masses in the abdomen. There was no fluid wave. Incision in right rectus muscle encountered large lobules of fat. These were removed in quantities until eighteen pounds of fat had been removed. After operation, he weighed forty-three pounds. The fat lay mainly between abdominal wall and peritoneum, the viscera being pressed against the spine. It invaded the space of Retzius and extended up around the left kidney. The mesentery was nowhere invaded except at the left side of the transverse mesocolon. The peritoneum was torn anteriorly and sutured. No blood-vessels were ligated. Practically all the fat was removed from the abdomen. He made a good recovery and is now a well-nourished instead of an emaciated child.

PYELO-NEPHROLITHOTOMY—SECONDARY HEMORRHAGE. AVOID-
ANCE OF NEPHRECTOMY BY REPEATED SUBCUTANEOUS
INJECTIONS OF HUMAN BLOOD SERUM

DR. WILLY MEYER presented a patient in whom he had done pyelonephrolithotomy for stones in the pelvis and parenchyma of the right kidney. The section cut of the upper two-thirds had revealed a small focus with a nest of quite a number of stones.

The kidney was sutured with chromicized gut through and through in the usual way. Five days after the operation a pronounced hemorrhage set in, which was followed by two others. Inasmuch as the kidney had proved to be healthy, nephrectomy was not favored, and an attempt was made to combat the hemorrhage by repeated injections of human blood serum as follows: first 500 c.c. were given within three days; three days later 100 c.c. and again after ten days 375 c.c. within two successive days. This decreased the coagulation time to four minutes. With careful after-treatment the hemorrhage did not return and the patient was shown in perfect health.

CHRONIC EMPYEMA

DR. WILLY MEYER presented a young girl who had been under his care for the last five years and had been presented before the Society a few years ago, when not yet cured. By persistent treatment which consisted in gradual exposure of the deep cavity which ran parallel to the spine, the deep groove had at last been brought to cicatrization. There was still a small bronchial fistula beneath the inner border of the scapula, which it is intended to keep open for some time.

The patient, who had had empyema, following pneumonia, ever since

DISINFECTION OF WOUNDS WITH CHINOSOL AND SALT

she was four years of age, and had been operated upon four times before she came under Doctor Meyer's care, without the cavity being closed, is now at last to be considered cured, after twenty-two years of suppuration.

DR. NATHAN W. GREEN said he had seen quite a number of similar cases, worked on them and followed them up; and it appeared to him most important that these operations should be done in stages. There frequently is a spontaneous diminution in the size of the cavity up to a certain point provided drainage is ample. It is well not to operate on these cases until they have been given some length of time for drainage. Then the cavity is much smaller and not quite such a wide resection of ribs will have to be done.

EXTRAPLEURAL THORACOPLASTY FOR ADVANCED PULMONARY TUBERCULOSIS

DR. WILLY MEYER presented a man, thirty-one years of age, who had been suffering from left-sided pulmonary tuberculosis for the last four years. When he came to New York in the early part of November, 1918, he suffered from frequent sudden attacks of high fever, expectoration, rapid pulse and great weakness. There was multiple cavity formation in both lobes, particularly the upper. Artificial pneumothorax proved impossible on account of extensive adhesions between the two lobes of the pleura. This was the reason that he was sent from Saranac Lake to New York for operation. It was decided to do thoracoplasty in two stages. On November 18 the tenth to sixth ribs were resected (6 to $7\frac{1}{2}$ inches) under regional and local anæsthesia with $\frac{1}{2}$ per cent. novocaine. This was nicely feasible. On December 10, the second stage was added with resection of the fifth to second ribs of from $2\frac{1}{2}$ to $4\frac{1}{2}$ inches.

Soon after each operation external compression with a pad and elastic straps was added. The patient made an uneventful, speedy recovery, and has been very markedly benefited by the operation. The tubercle bacilli and the fever have disappeared, the cough is much reduced and the patient's strength has increased. He now intends to return to the mountains.

THE DISINFECTION OF VITALIZED TISSUES AND THE HEALING OF WOUNDS WITH CHINOSOL AND SALT (A PRELIMINARY REPORT)

DR. WILLIAM C. LUSK read a paper with the above title, for which see page 493.

Doctor Lusk said in closing that among the merits of chinisol in combination with salt, were its stability, its ease of application, it being applied to an accessible wound by means of gauze laid in contact with the surfaces of the wound, its tendency to dry pus up, its non-irritability when applied in accordance with the technic here advocated unless possibly after prolonged use; also the facts that it appeared not to attack tendons and that it facilitated the separation of sloughs.

TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting held February 13, 1919

First Vice-President, DR. GEORGE G. ROSS, in the Chair

CHOLECYSTITIS FOLLOWING TYPHOID FEVER IN CHILDHOOD

DR. HARRY C. DEEVER read a paper with the above title, for which see page 534.

PYLORIC STENOSIS IN INFANCY

DR. FRANCIS O. ALLEN read a paper with the above title, for which see page 531.

DR. HENRY R. WHARTON said that in the cases of pyloric stenosis seen by him a peculiar feature is the very distinct tumor which seems to be about the size of an ordinary shellbark hickory nut and which when divided separates almost like cartilaginous tissue. Doctor Allen spoke of a case in which he failed to find a pyloric tumor but did find adhesions. A few days ago the speaker had a case at the Presbyterian Hospital which had many of the symptoms of pyloric obstruction but in which they failed to palpate a tumor. The gastric peristaltic wave was present. Operation revealed no distinct pyloric tumor, but the pyloric end of the stomach was firmly adherent in the region of the gall bladder, and was separated with some difficulty. The following day the patient was doing very well, had no vomiting up to the time of his death. At the end of the third day the pulse failed and the patient died but presented no abdominal symptoms. Attention has been called to the fact that in these cases a certain number die with marked thymus symptoms. There seems to be some association between cases of thymus gland enlargement and pyloric tumor.

DR. H. C. DEEVER said that during the last five years thirty-four cases of pyloric stenosis had been under care at the Children's Hospital of the Mary J. Drexel Home. Dr. John B. Deaver and the speaker had operated upon an equal number.

In the early cases they did a posterior gastro-enterostomy for this condition, with a mortality of 18 per cent. During the past two years they have been doing the Rammstedt operation.

The youngest patient, a child six days old, was born in the Lankenau Maternity by Cæsarean section. This child vomited continuously until the sixth day, when he was operated upon and a congenital stenosis demonstrated.

The Rammstedt operation is a very simple one, entailing little shock

and requiring not more than fifteen minutes for its performance. The amount of shock depends largely upon the condition of the child.

In their early work for this condition these children were emaciated and very poorly nourished, but during the last two years pyloric stenosis is being recognized, and hence these cases are being referred for operation much earlier than heretofore, and for this reason they are better subjects for operation.

Since they have been doing the Rammstedt operation their mortality has been 10 per cent. Hemorrhage has been a factor in this mortality. In releasing the stenosed pylorus care is necessary to guard against opening the lumen, especially at the duodenal end, where the bowel is very thin. This accident had happened to him in two instances. In both instances he promptly closed the perforation with no ill result.

He makes his incision through the anterior surface of the stenosed pylorus, making the incision parallel with the small vessels which run through the peritoneal covering; and, where there is bleeding, he transfixes the vessels and ties them. He never drops the pylorus back until he is sure that all oozing has ceased.

Regarding diagnosis, the only cases they get are those sent in by the pediatrician, the family physician never recognizing the condition. As a rule, these children are always emaciated and poor subjects for any operation. Fluoroscopic examination is a great help in confirming the diagnosis, and it also converts the skeptical.

Some writers say that the absence of bile in the vomitus is pathognomonic; he does not think this is so because the fluoroscopic examination has demonstrated in several instances the pylorus not completely obstructed. There has been absolute constipation in all their cases.

They had had two cases where the incision opened up on account of the sutures giving way. He now uses through and through silkworm sutures, not removing the sutures for ten days to two weeks.

In the thirty-four cases operated upon the diagnosis in each instance was confirmed by the operative findings.

The oldest child operated upon for pyloric stenosis was six months of age; the majority of the cases have been from six to ten weeks old.

DR. E. L. BAUER said that the diagnosis of pyloric stenosis in practically all the cases he had seen in the services of Drs. Harry C. and John B. Deaver had been rather easily made. He had seen some cases in the dispensary and some outside. If there has been any question in diagnosis the fluoroscopic examination was made and the cases studied carefully, not, however, losing any time in this study. He was not in sympathy with the attempt to feed these children as suggested by many pediatricians. Practically all such methods fail. He believed the cases to be essentially surgical and should be referred to the surgeon promptly before the chances of benefit are lessened by temporizing with medical treatment. There is always a question of doubt in diagnosis in unoper-

ated cases, particularly those that are reported as having recovered. In all the cases operated on by Doctor Deaver the pylorus was shown to be hypertrophied. Medical cases reported as recoveries are usually instances of digestive disorders in children simulating stenosis. The typical case is not likely to be overlooked. In a case at Hammonton seen in consultation by an acquaintance, the mother of the child had made the diagnosis from the text-book. If the family physician is taught that these cases should come to the operating table early the mortality records will be considerably reduced. The six-months-old child operated on by Doctor Deaver came into the Mary Drexel Home through one of the doctors on the surgical staff at the Lankenau to whom it had been referred. The child was extremely emaciated and in bad condition. The operation was attempted but with not much hope of securing good results. The child survived the operation and did well for about six weeks. It was thought that it should be kept in the hospital rather longer than the average child in order to feed it, but as with many of the cases staying long in the hospital, it picked up an infection and died of broncho-pneumonia six weeks after the operation.

DR. ALLEN, in closing, spoke of a case which he had not reported, that of a girl five years of age, who, he was convinced, had pyloric stenosis, but he was not able to prove it. There was enormous distention of the abdomen. The child was under the care of a physician during its life, being seen by him from time to time, and there was always present more or less stomach trouble. The distention was enormous. The child was having great difficulty in breathing, and though Doctor Allen could not offer any great hope of benefit, he thought he might relieve the distention by making an abdominal incision under a local anæsthetic and puncturing the bowel. He found that the distention was all in the stomach; the posterior wall of the stomach presented below the umbilicus. He put in a trocar and let out an enormous quantity of fluid and gas, but the child died before he could do anything further. He did not enlarge the incision to see what the difficulty was. The history suggested a pyloric obstruction and the distended stomach corroborated the diagnosis, but he could not say positively that a tumor of the pylorus was present.

BOOK REVIEWS

DR. JOHN RADCLIFFE. A Sketch of his Life with an account of his Fellows and Foundations. By J. B. Nias, M.D., M.R.C.P. Clarendon Press. Oxford. 1918. Octavo; pages 147; cloth.

This beautiful little book is a replica of the best style of Eighteenth Century typography.

To appreciate it one must review the English history of that period and particularly the reign of Queen Anne and the personality of the queen herself. One must be familiar, also, with the social conditions of England which at that time made a career, such as that of Radcliffe, possible. Nothing can contribute to the latter more than the re-reading of the charming little book "The Gold Headed Cane." Indeed, upon the front cover of the present book is embossed as an ornament a cut of the gold-headed cane of Doctor Radcliffe which descended to Mead, Askew, Pitcairn, and Baillie, to finally obtain a permanent resting place in the Archives of the Royal College of Physicians of England, where it is at present.

The book opens with a brief sketch of the life of Doctor Radcliffe (1650-1714). A notable postscript to the sketch of Radcliffe is the reference to the account of the steward of the doughty doctor, from which it appears that at the height of his professional career Radcliffe used to send to his banker every ten to fourteen days a round sum of 100 pounds, presumably after meeting all his current expenditures, as in those days men banked merely for the purpose of investment.

The same book also contains the names of a number of Doctor Radcliffe's patients, with a record of the medicines prescribed for them. That he was more shrewd than learned, may be inferred from the anecdote told of him, which, though it has been told of others, perhaps had its origin with him. Radcliffe on one occasion said to Sir Thomas Millington, a man whom he could not fail to respect, that "the whole art of medicine could be put on a sheet of notepaper." Millington replied: "As far as you know, it could." Whatever the scientific attainments of Radcliffe may have been, he made a profound impression upon his period and amassed a fortune which he bequeathed to Oxford University.

Among other provisions of his will was the one by means of which he provided for two Medical Fellowships whereby two persons who were chosen out of the University at Oxford, men who had received the degree of Master of Arts "and had entered on the Physic line," should receive 600 pounds yearly for ten years, one-half of which time they were to travel in parts beyond the sea for their better improvement. These fellowships, therefore, could be awarded only every ten years, but in later years the

period of the enjoyment of the fellowships was reduced to three years and the number of fellowships were increased to three. The greater part of the present book is taken up with a chronological list of these Radcliffe fellows together with a short sketch of the life of each one of those who have occupied these positions from their foundations in 1715, down to the present time.

As one looks over this list, the impression is unavoidable that such foundations fail utterly of accomplishing anything specially noteworthy. Is it not true, that if one takes up the whole list of fellowships and prize men which one may find in the history of various foundations and societies, which were supposed to be incentives to labor and expected to be prolific of scientific attainment, is it not true that they are almost absolutely barren of permanent results of value? Scientific inquiry, scientific discovery, scientific enthusiasm, have thus far, at least, never resulted from endowments and prizes; rarely has the opportunity for study which these things present found its happy conjunction in the special mental conditions which would have made such opportunities fruitful.

The book, likewise, gives a history of the Radcliffe library, one of the ornaments of Oxford at the present time, and also of the Radcliffe Infirmary which, perhaps, has been the most useful and fruitful of the foundations which resulted from the fortune won by Dr. John Radcliffe. The book as a whole is an extremely interesting and attractive record, and will be sure to command the attention of the medical historian.

UNITED STATES NAVAL MEDICAL BULLETIN. Special Number. Report on Medical and Surgical Developments of the War. By WILLIAM SEAMAN BAINBRIDGE, Lieutenant Commander Medical Corps, United States Naval Reserve Force. Published for the information of the Medical Department of the Service at the Bureau of Medicine and Surgery, Navy Department, Washington, Government Printing Office, 1919.

This special number forms an octavo volume of 250 pages. It well illustrates the general policy of the Medical Department of the United States Government during the recent war to keep its medical officers fully informed of all phases of medical and surgical development which could be of use to them in carrying on their work for the relief of the sick and wounded of the Army and Navy. The present volume consists of a series of reports by Lieutenant Commander William Seaman Bainbridge. It is based upon observations made along the western front in England during 1917 and the first six months of 1918, under instructions of the Surgeon General of the United States Navy. To these are added data obtained while in Germany during the autumn of 1915. The experiences of the British, the French, the Belgians and the Americans in active war service are summarized. The result is a compilation of the highest interest and of great value. It is very fully illustrated by many photographs.

BOOK REVIEWS

The progressive phases presented by the war in the treatment of wounds naturally forms the first essay. There are here detailed the history of the experiences leading up to the final perfected methods of operative treatment and primary suture of war wounds. The book discusses fully the Carrel-Dakin treatment and the value of such other preparations as eusol, Dichloramin-T, magnesium sulphate, "Bipp," Flavine, crystal violet, the salt pack and hypertonic solutions, the sunlight treatment, the employment of various forms of electric current, and the uses of oxygen and ozone. The whole forms an interesting and valuable resumé of most of the attempts at wound treatment which were made during the war.

In the treatment of wounds of the joints, the method of Willems is fully discussed and illustrated. Fractures, trephined cases, and amputations, each have sections devoted to them. The Department of Plastic Surgery, especially in overcoming facial deformities, is fully treated and very abundantly illustrated.

The provisions made for the care of the wounded from the firing line to the convalescent camp form an interesting section of the book. The cuts which illustrate this portion of the book are of extreme interest and are of permanent value in preserving the record of the conditions under which relief to the wounded was carried on in this contest. Every department of work is pictorially set forth, such as the application of first aid on the field, the arrival of the wounded soldier at the first aid post, the interior of an underground dressing station, the general view of an evacuation hospital, the railroad ambulance train, the hospital ship and a transformed canal boat occupied as a ward; and finally, the more imposing base hospitals secured by transforming hotels and chateaus into places for the care of the sick, or the great pavilion assemblies, such as that constituting the great Red Cross Hospital at Netley, England.

The provisions for the re-education of the disabled then engage attention. A full statement is made of the provisions for the relief to as great a degree as possible, of those who were maimed, but who after recovery from the results of the immediate injury, remain more or less helpless and dependent upon others. One of the most notable developments of public sentiment originating in this war has been the practical character of the efforts which have been made to teach this group of survivors of the war to make the most of what remained of them after the losses which they had sustained and to so help them to become active participants in the affairs of life. What is being done along this line is set forth very fully and clearly and illustrated very largely.

Lieutenant Commander Bainbridge has certainly succeeded in bringing together a report of the highest interest and value.

SIR DAVID BRUCE on Tetanus. At the session of the Research Society of the American Red Cross in France held in Paris, October 4-5, 1918, reported in the December issue of "*War Medicine*," Major General Sir David Bruce, of the British Army Medical Corps, in discussing tetanus expressed the opinion that the surgeon's knife stands in the first rank as a prophylactic. The first and most important measure in the prevention of tetanus is the thorough surgical treatment of the wound at the primary operation.

As to prophylactic injections of antitoxin, four injections of 500 units at each dose at intervals of seven days are recommended by the British Tetanus Committee. This was the original recommendation of the committee, and General Bruce says that he still remains of the opinion that the recommendation is correct, although a practice had recently become prevalent to raise the primary injection to 1500 units, while the second, third and fourth injections remained at 500 units. The prophylactic value of such repeated injections is beyond all doubt since there has sprung up experimental evidences that after about ten days the immunity conferred by an injection is to a great extent lost. While there can be no shadow of a doubt as to the effect of the prophylactic injection of antitoxin, the antitoxin as a curative agent stands upon an entirely different basis. The reporter says that in fact, there does not seem to be any statistical evidence that serum given therapeutically has any marked effect on the rate of mortality. It seems to be admitted that tetanus toxin which has been taken up and fixed by the nerves or nerve cells, is inaccessible to antitoxin. If a lethal dose has been taken up by the nerves and is traveling towards the nerve centres before the serum treatment is begun, then no amount of antitoxin will save the patient, although it may neutralize some of the free toxin in the blood and lymph and prevent its ultimately entering the nervous system and causing death, when the toxin already admitted through the motor nerves is not sufficient to do so.

As to the best route for the injection of antitetanic serum in acute general tetanus, the best method of treatment lies in the earliest possible administration of large doses of antitetanic serum by the intrathecal route. A reasonable and suitable dosage is about 16,000 units on the first and second day given intrathecally, and about 8000 units given intramuscularly.

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THE INFLUENCE OF WAR SURGERY UPON CIVIL PRACTICE

PRESIDENT'S ADDRESS BEFORE THE AMERICAN SURGICAL ASSOCIATION, JUNE 10, 1919

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WHEN at the opening of the Congress of the International Surgical Society in New York in April, 1914, President Depage announced as the theme of his inaugural address "War Surgery," it came as a distinct surprise to the great mass of those who were assembled to listen to him, for nothing was farther from the thought of the scientific world at that moment than War. Indeed, the very existence of the society before whom the address was being made was an evidence of the universal expectation of a continuance of that peace which for so many years had prevailed among the controlling nations of Europe. In the assembly to which his words were addressed were eminent representatives of England and France, of Belgium and Germany, of Russia and Italy, of Denmark, Norway, Sweden and Finland, of Austria, Poland and Hungary, of Holland and Portugal, and Roumania, all guests of the surgeons of North America. Was not such an assembly a guarantee of the continuance of that peace of the triumphs of which those men were such eminent representatives? And yet, before the pages of that address appeared in print, the fateful third of August had arrived and the world was plunged into a strife which arrayed these men as enemies, each to the other; was to array in battle sixty millions of men and was to cause the direct loss from the world's workers by death on the battlefield, or later from the wounds there sustained of more than ten millions of men.

Five years have passed, years the most tragic and historic of all the centuries. All of those men who were our guests five years ago have been compelled to devote their entire thought and labor during these years to the surgery of war. Some of them have suffered the supreme sacrifice which war exacts from its devotees. Of the active members of the American Surgical Association itself a large proportion have worn the uniform of their country's service, and of the remainder there is not one who has not regretted that, by reason of years or by reason of the importance of civil duties which could not be transferred to other hands, it has been impossible for him to follow the example of his younger colleagues.

To-day we are in expectation of approaching peace and it is possible for us once more to concentrate our thoughts upon the problems and

duties of ordinary life. We welcome again the appearance among us of our colleagues who have been in service abroad, as well as those whose duties have kept them in the encampments at home. The memories of the past and the pleasures of the present in this reunion unite to give to this meeting of our association a special spirit in which interest and pride and affection, memory and anticipation, unite to form a bond that brings us more closely together than ever before.

It is with the highest satisfaction, also, that we welcome the presence of representative surgeons from such countries as Belgium, France and Great Britain, to help whom in the tremendous burdens which the recent strife thrust upon them, has been the glad opportunity of so many of our number, and whose unfailing courtesy and grateful appreciation has been demonstrated to their American confrères in so many ways and upon so many occasions. We feel that we are honored by their journey across the Atlantic to be present at this meeting and we extend to each of them our cordial greeting and fullest homage, and through them we send to the countries which they represent our most grateful appreciation of the years of struggle and sacrifice which they have made in their labors to protect the world from an assault aimed at the foundation principles of civilization, a strife to share in which it was ever our duty and finally our privilege.

It is proper that we should pause a moment to do honor to the memory of those colleagues of our own blood who in this recent contest sacrificed their lives in obeying their country's call. From first to last nearly 35,000 American physicians donned the khaki and the blue of the Army and Navy as a patriotic duty. To by no means all of this number¹ was it given to go overseas, and of those who did cross the Atlantic a very considerable portion were prevented by their duties from reaching the front before the sudden and unexpected collapse of the enemy power removed at once the need for that service. All alike, however, were animated by the same spirit, and to all are due the credit and honor which belongs to the highest professional zeal and deepest patriotic devotion.

It is impossible to speak in too high terms of the character of the personnel of which the Medical Corps of the American Expeditionary Force was composed. They were men, not only inspired with patriotic devotion and filled with the hopefulness and progressiveness of youth and early manhood, and possessed of ability to endure hardship and labor, but in large proportion they were men of thorough and long training, many of them of large hospital experience, many specialists of distinction, keen in their professional spirit, enthusiasts in their work, ready and eager to cope with the surgical problems, however colossal, which demanded attention and solution. Of these, our companions, our pupils, in some cases our sons,

¹ The total number of officers in the Medical Department sent overseas is as follows: Medical Corps, 14,358; Dental Corps, 1924; Veterinary Corps, 887; Sanitary Corps, 1333. Total 18,494.

INFLUENCE OF WAR SURGERY UPON CIVIL PRACTICE

who were of that number who were privileged to share the dangers of the enemy's offensives, 46 were killed in action; 22 died later of wounds received in action; 212 received wounds from which they survived; 38 were taken prisoners, 7 are registered as missing in action, and 4 were lost at sea. This is a record which would do honor to any body of men and is especially splendid for men deemed to be noncombatants; who were animated not by the special enthusiasm of combat, nor by the expectation of military fame or reward, but by that professional spirit peculiar to medical men which has ever caused them as a class to ignore danger and fatigue, and inconvenience of any kind in the performance of duty. The duty of the surgeon is ever to save life, to relieve the suffering, and when, in the performance of such duty, he loses his own life, does he not illustrate in the highest degree the spirit of the Great Teacher, "Greater love hath no man than this, that a man lay down his life for his friends"?

For the first time in supposedly civilized warfare, hospitals were selected as the special target of attack by an enemy's gun. The Red Cross was no longer sacred and the operation pavilion, or a nurses' home, was the object of an aerial bomb, as much as an ammunition train, or a depot of military supplies.

With reason, therefore, do we claim that the medical officer of the front and those assistants of humbler rank who shared his dangers and his labors are among the heroic figures of the war to whom due honor should ever be paid. It has well been said that none who have not experienced the stress, the anxiety and the limitations of surgical work during severe fighting can appreciate the problems and the difficulties of the work which had to be done under such surroundings; to which should be added as well, the dangers which they shared equally with those who were recognized as combatants.

To the memory of those of their number who under such circumstances lost their lives, their colleagues cannot pay too high honor. Those who sealed their devotion to duty, their patriotic fervor and their professional enthusiasm with their blood, who sleep now beneath the sod of a foreign soil, these are *our* heroes. They belong to a legion of honor more illustrious than that of any modern government; they wear a decoration of special merit awarded to them by their fellows of a universal brotherhood who best and most fully understood their merit. The cross that marks their graves indicates a distinguished service of which no other badge could be more significant. We honor ourselves as we hasten to place about their names ever renewed chaplets of laurel!

The war is over and we may now turn our thought as surgeons to garner its lessons, estimate its results, and place to future practical account its teachings. Animated by this idea, I have chosen as a theme suitable for the Presidential Address in this Victory Year, "The Influence of War Surgery on Future Civil Practice."

I am not unmindful of the fact that we are yet too close to recent

events to fully appreciate them in their proper relations, or to know what the ultimate influences that they may exert may be. Still there are even now certain things that are plainly discernible, and it is inevitable and advantageous that we should begin at once to take account of the new conditions and possibilities that have been demonstrated in the peculiar and vast experience of these years of warfare, and to speculate, also, upon the future changes which present conditions indicate. From many angles may be viewed the influence of the experiences gained in such conditions as those supplied by a war of such magnitude as the one through which the world has just passed, even when attention is confined to the single field of surgery, but it is only upon some of the larger, broader lines of the subject that I shall dwell at this time.

In this connection, the effects produced in the professional life and character of this country by the four years of the Civil War of 1861-1865, naturally at once present themselves to the mind of one who had a part in the experiences of that time and has been able to see and feel the effects which that war produced upon American surgery. This association is fortunate that among its Senior Fellows still remain some men who personally shared in the labors of that great war. Keen and Vander Veer, Nancrede and Weir still survive to benefit us with their counsel and to recall to our memory the trials and accomplishments of those days. May we not look to them now as to "Elder Statesmen" to strengthen, to judge, or possibly to correct, my own estimate of the effects upon civil practice of the surgery required and developed in the conditions of war?

The effects of war upon surgery and surgeons and upon the attitude of the public mind to surgery and surgeons is a fairly certain reaction. The times and men change, but the general effects are the same. Before 1861 the field of surgery in this country was a very narrow one.

The traumatic surgery which resulted from the battlefields of the war for the Union awakened the slumbering surgical spirit of the American medical profession, and when peace was declared in 1865 there returned to their homes, North and South, more than 25,000 medical men who were familiar with the most exacting of surgical emergencies to meet which they had been trained in conditions that called forth quickness, fortitude and self-reliance in an eminent degree. Their confidence in themselves had been awakened, their energy and experience had been broadened and their interest in surgical problems had been increased. But not alone was this surgical baptism enjoyed by commissioned officers. There was a great host of enlisted men who by reason of their hospital experiences, as patients, as nurses, as ward masters, as hospital stewards, had been made familiar with surgical work and had had their interest aroused in its problems, so that during some years immediately succeeding the close of that war, the medical schools of the country were crowded with men whose interest in medicine and especially their enthusiasm for surgery,

had been awakened by the experiences of that war. Hardly had these men returned to their homes, military surgeons and the graduates of army hospital wards, when the Listerian teaching was announced to the world. The relations of microorganisms to infection, and of infection to surgical catastrophes, were demonstrated, the whole field of surgery was immensely enlarged and there was presented to their eager minds a fallow field inviting their labors, the results of which were no longer uncertain and capricious.

One of the by-products of this awakening of the surgical spirit in the American profession was a constantly increasing appreciation among its leaders of the desirability and importance that the surgery of America should have a representative body. This fully culminated, finally, in the conference at Atlanta in 1879 at which the American Surgical Association was born. What a peace conference that was, when from New Orleans, Mobile, and Charleston, Boston, New York, Philadelphia, and Cincinnati, Chicago, San Francisco, St. Louis, Louisville, Nashville, and Richmond, assembled surgical leaders who a few short years before were arrayed against each other in fratricidal strife, now to unite in the formation of an association which was to typify a united America! It is not too much, indeed, to say that the very existence of the association which has called us together to-day, is one of the effects of "War Surgery Upon Civil Practice."

It is along similar lines, therefore, that I am inclined to think will be found the most important effects upon civil practice of the surgery of the recent World War. Surgeons of this war, after the experiences which they have had, both in the more trying conditions on the fields of combat and in the highly important demands to which they have been subjected in the base hospitals both abroad and in the cantonments of concentration at home, cannot escape the higher endowment which attends the enlargement in the scope of their surgical vision; which inevitably has heightened and broadened their professional aspirations, and which has resulted in a higher grade of attainment both in the science and art of their chosen profession, and which has greatly increased their usefulness as individuals in bringing relief to their fellow men. Perhaps the chiefest element in this mental change which has steadily grown out of the conditions of their daily work is an appreciation of the value of co-operation with their fellows to the end of diagnosis and *pari passu* with this an increase of mutual respect and a lessening of individual rivalries and an increasing devotion to the highest attainments of science. The most important effect of the recent war was upon the surgeons rather than upon surgery. Never before in the history of warfare have the merits and value of the medical staff for consideration as parts of the military machine been so fully acknowledged as in the war now closed. This has had its most marked evidence in the increased rank given to its

surgeons, for in an army there is one unfailing criterion as to the importance of a man and that is *rank*.

I have recently been rereading Fielding Garrison's charming and sympathetic biography of our late colleague, John Shaw Billings. Billings was commissioned an assistant surgeon in the United States Army in April, 1862. He was soon in charge of a great base hospital in Georgetown. He later was assigned to field duty with the Army of the Potomac, and had large responsibilities in the care of the wounded from the battles of Chancellorsville and of Gettysburg. As an inspecting medical officer, he was charged with important duties during the campaign of the spring of 1864, and finally, was assigned to duty in the Surgeon General's Office at Washington in December, 1864, where his erudition, his intellectual poise, his judgment of men, his unremitting industry and his great administrative ability enabled him to be of such great service to his country and to his profession for the succeeding fifty years. And yet, Billings, with his ability and his record saw no promotion in military rank during all the years of war. As an assistant surgeon, with the rank of first lieutenant, he entered the army in 1862, and he was still a first lieutenant when the victorious hosts of Grant and Sherman made their triumphal march down Pennsylvania Avenue in 1865!

I cite this case to contrast it with the different treatment accorded to the medical corps in this most recent of wars, in which there appeared a willingness to grant to medical men degrees of rank suitable to the responsible and important duties belonging to them, an appropriate acknowledgment of the inseparable qualities of hygiene and surgery as handmaids to sound strategy and combatant force to ensure ultimate victory. I take it, my colleagues, that this is a consideration that concerns us so much, both as citizens and surgeons, that we might well express our appreciation of the wise and admirable methods whereby this most desirable and important change has been accomplished.

I mention it now, however, because of its place in the chain of conditions that have an important influence upon the character of the surgeons who have so recently shared in the military spirit of their country's armies. It has to do with that intangible, undefinable, altogether admirable thing which we call "*morale*" which is the surest precursor of success and the most important element in the attainment of ultimate victory. Nothing contributes to it more than a sense that those for whom we labor, confide in us, depend upon us, honor us. In the military life this has its highest expression in what is called *rank*. The American Congress, when it established in the medical corps of the recent army the higher grades of rank with which it is now honored, at once not only gave to that branch of the service the recognition which its importance deserved, but with it increased in a notable manner the morale of the whole service, as it granted to so large and important an element of it such assurance that it confided in it, depended upon it, honored it. Every member

INFLUENCE OF WAR SURGERY UPON CIVIL PRACTICE

of the medical staff of this army has felt the influence of this new attitude of their government to them, and each one in returning to his home and resuming the duties of civil life, will continue to feel its broadening and stimulating influence to a higher degree of professional work.

The compactness of the territory within the limits of which the chief contests of this war have taken place; the comparative stability of the areas of combat and the great prolongation of the struggle made it possible for the surgeons of the forces from all parts of the extended front, by mutual conferences affording personal exchange of experiences, to early establish a progressively improving standardization of methods of practice; a standardization which contributed greatly to the remarkable degree of efficiency ultimately attained. The various allied governments apparently vied with each other in effecting organizations that could provide to the fullest possible degree for the needs and exigencies of the demands of their armies for surgical relief, including hospitals, matériel, literature, and methods of supply and of evacuation, all of which contributed greatly to the encouragement, the inspiration and the positive assistance of surgeon and patient. The ubiquity of the organization and the instant readiness with which the agents of the Red Cross responded to emergent calls for helpers and for supplies of every kind wonderfully supplemented the slow movements through official channels. Each element, official and volunteer, contributed a share in bringing about the results of the surgery of this war, as each has been an element in making possible the final measure of successful relief secured.

To one who has occupied a point of view so peculiarly detached and so broadly and deeply sympathetic as that in which your speaker has been placed, who from the circumstances of his own early years of military service ashore and afloat, in time of war and in time of peace, has been able to realize the many-sided character of the relations of surgical organization and of surgical work in the military ensemble of the great war, the one great thing that stands out as the preëminent feature in the surgery of this latest war is the fullness with which the military importance of the provisions for surgical relief and sanitary prevention has been recognized by the governments involved. We may be sure that there will be no step backward in the future. The magnificent results which the surgery of the war has shown have forever closed the mouths of those who would belittle the position of the "Doctor in War." The thought which is in my mind in this connection, however, has to do more especially with the effect upon the medical men themselves which this recognition has produced.

When the newly appointed medical officer first entered the training camp to which he was sent, he began at once to appreciate that he was a part of a great military machine whose spirit he must imbibe, in whose labors he must bear an important part and in whose glories he was to share. The transformation in his mentality, in his sense of relation to his

fellows, in his grasp of the real values of life's problems which rapidly took place in him, can never be reversed. When he is finally mustered out of the service and resumes his life as a civilian, he does not and cannot return to the same status which he occupied when he first assumed the military dress. There has inevitably been awakened in him a divine dissatisfaction with the old life and a longing after a higher standard of professional attainment and life. His professional spirit has been heightened, strengthened and chastened. This direct fruition of war-time conditions has been experienced by some in greater degree than by others, but no one has escaped its influence in some degree. This, then, is the highest, most important, most beneficent of contributions of the surgery of this war to the civil life of the nation, namely, a quickened, ennobled, more efficient body of surgeons; a body of men who in the hard school of war have received an endowment of enthusiasm, an illumination of spirit, and an ability to persevere and conquer success under difficulties which they will carry with them during the remaining years of their life, and which qualities in some measure they will transmit to, or create in their successors.

Without in any way minifying the extraordinary results which have been attained in the surgical efforts of this World's War, is it not true that in general these results are but demonstrations and applications, though often upon a colossal scale, of principles and truths which the work of the previous fifty years had been accumulating for its use, rather than the development of any new and important principle which, with the disappearance of the special conditions of combat destructiveness, will remain to us as a permanent addition to surgical practice to modify the surgery of civil life hereafter?

The traumatic surgery of this war has constituted a tremendous vivisection experimental laboratory in which not mice, nor rabbits, nor guinea pigs, nor dogs have been the subjects of experiments, but human beings, the choicest young men of the civilized world. To the solution of the problems of the surgery of the last and greatest war was concentrated the experience, the researches, the labors, the maturest surgical thought of all the years to which the traumatic surgery of 1861-1865 was a prelude, years during which surgery became so largely a science, definite, positive, certain, as well as an art, wonderful and merciful in its results.

It is true that the exigencies of war have produced many modifications and adaptations of surgical technic. New antiseptic agents and combinations have been introduced. The scale upon which work has had to be conducted has been immensely enlarged beyond that ever called for in civil practice. The wounds which had to be cared for, as a rule, presented more extensive lacerations and were the subject of more intensely virulent infections than had ever before been met with in warfare. The urgency of the work has been at times overwhelming and the provisions for desirable technic were often unavoidably inadequate. Notwithstanding

ing all these facts, we now see that through the perfection of the organization of surgical relief which was accomplished the results of the surgical methods adopted for the treatment of this vast traumatic surgery were better than those witnessed ever before in warfare. It is true that in the urgent stress of combat conditions, there was often haste and crudity in the methods employed. The shifting battle conditions produced at times an enormous disproportion between the demand for work and the possibility to respond to it. There were days of unavoidable irregularity and urgency of demand that discounted all anticipation, but never before was so perfect an organization evolved for bringing early and adequate surgical relief to the wounded.

The stations for first aid, the casualty clearing stations and the base hospitals, formed a series of provisions for relief that provided in succession for supplying the needs of every emergency in the progress of the wounded man from the reception of his injury upon the open field or in the trench to his ultimate return to duty as a cured man in a degree that compels our astonished admiration at its fullness and its success. It is true that in the earlier days of inexperience and confusion there was registered much of disappointment and failure in the provisions for relief that were made. We do not close our eyes to the enormous amount of suppuration and gangrene which developed in the wounds of that time. The manner in which, however, these conditions were mastered and the reasons for them appreciated and overcome, and the ultimate success of the surgery attained, forms one of the most remarkable and triumphant chapters in the history of surgery.

The accumulated statistics of the war, notwithstanding all its inevitable disasters and failures, show that more than 93 per cent. of all wounded men who lived to come under surgical care recovered from their wounds and that from 70 to 80 per cent. of all casualties were able to return to duty within two months.

Any study of the specific details of the practical surgery which was elaborated and carried out to bring about such a result cannot be entered upon at this time. These details form chapters in the surgery of war which will ever be of the highest importance, not only as presenting surgical effort in its most exalted phases, but also as lessons of supreme value in directing the surgery of the future, not only in conditions of warfare, but in the civil practice of times of peace. The careful studies of the subject of shock, with its demonstration of the possibility of carrying on, even in conditions immediately behind the line of battle, such a procedure as blood transfusion, the widespread, almost universal use of prophylactic injections of the antitoxin to forestall tetanus, the practical establishment of minute details whereby sepsis was controlled and anti-sepsis made efficient, and above all, the demonstration and universal adoption of methods of early surgical resections of wounds whereby they were converted into clean wounds, the ultimate healing of which was no

longer an uncertain and prolonged process, but became a sure and rapid exhibition of primary healing; and those results which were obtained by the surgery of various regions, the surgery of the brain, and that of the peripheral nerves; the surgery of the face, the surgery of the chest, as the result of which the thorax, which always had been practically a closed area to surgical effort, was demonstrated to be as accessible and as promising a field as any other portion of the body; the abdomen and the extremities, with which latter are associated the problems of bone and joint infections; all these have already been the subject of intensive studies, in each department of which most important contributions have been made by Fellows of this Association who now sit before me. These in their order and place will occupy our interested attention for years to come.

It is most notable that steadily from the beginning to the close of the conflict in every line of effort, better and better results were being secured and more successful responses to the emergent needs of wounded men were being made. Who can say how great a contribution in the production of the magnificent morale of the allied troops which carried them on to final victory was the knowledge which these men had of the care which they would receive should wounds and disease overtake them?

With full appreciation of the record which surgery has made in this vast school during these four years of intense strife, is it not true that they present, not so much, the wonderful results of new discovery, or the brilliant work of some group of extraordinary surgical geniuses, but rather the constant, full value of sound surgery, the possibility of applying even in the conditions of combat fundamental surgical principles, worked out by a body of men endowed primarily with the elementary surgical instinct, but now illuminated and heightened by the peculiar influences of patriotic fervor and high ideals, and made practically efficient by the trained coöperative work which in the highest degree the military conditions afforded?

In conclusion, may I not say that the highest service which war surgery shall have rendered civil practice will be to have perpetuated this same spirit among these men as they return to their various fields of daily life?

GENERAL CONSIDERATIONS AS TO THE TREATMENT OF WAR WOUNDS*

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AMONG the important scientific contributions which have been produced in the course of this war, those which pertain to surgery have been, perhaps, the most characteristic and the most productive of important results. They have impressed upon the treatment of wounds a new evolution which will make an epoch in surgery.

Observation has shown us in the first place, contrary to what had seemed to be established by previous wars, that in the great majority of cases wounds are infected, or, at least, contaminated. In consequence of this first dictum débridement became to all surgeons a formal indication of the first rank. In general, all wounds inflicted by war fragments or from grenades, as well as the wounds by shrapnel or of bullets, which produced serious lacerations in the interior of the tissues or were accompanied by an abundant bloody effusion, were freely opened up immediately upon the arrival of the wounded at a hospital organization sufficiently equipped. At the same time the contused and lacerated tissues which constituted a medium favorable for microbic growth were cut away with the greatest care so that there was effected a veritable "*épluchage*" of the wound before proceeding to its dressing.

As a complement to this surgical intervention, surgeons had recourse for awhile in grave cases to cauterization by the thermocautery, or by superheated air or by the application of a chemical. These various agents, however, were given up because of their unduly violent action.

Since January, 1915, we have followed at l'Ambulance de l'Océan débridement and épluchage, with primary suture, when the cases appeared to us favorable, or we have resorted to secondary suture, as soon as after their dressing the surfaces of the wound appeared to be clinically aseptic, although we did not possess at that time any formal index as to the evolution of the microbial flora in a wound, so that it was not possible for us then to build up a systematic method of procedure. The merit of having systematized scientifically the secondary suture of wounds belongs to Alexis Carrel, who at the beginning of the war put himself at the disposition of the *Service de Santé* of the French Army and was put in control at Compiègne of an experimental clinic of 80 beds. With the help of the chemist Dakin, Carrel sought for an agent capable of destroying the microorganisms in the depths of wounds, more efficient than any of the agents which had up to that time been recommended.

* Read before the American Surgical Association, June 16, 1919.

After a very minute study made by Dakin as to the relative value of a large number of antiseptic agents, Carrel chose the hypochlorite of soda which even in dilute solution has the great property of conserving the proteins and of preserving also its antiseptic power in the presence of blood serum and organic exudates. The great inconvenience of the sodium hypochlorite was its caustic action upon the tissues and particularly upon the skin. Dakin remedied this by preparing a solution of the hypochlorite of a determined strength perfectly steady and by neutralizing it with boric acid.

I need not detail here the preparation of the Dakin solution. I will dwell only upon two points.

1. The solution must be fresh, prepared from day to day.
2. Careful verification must be made as to its reaction and all preparations must be rejected which are not absolutely neutral.

But the method of Carrel does not consist alone in the choice of the solution of Dakin for the irrigation of wounds. The way in which this solution is employed constitutes an essential point of the method. The different steps of the method as finally used by us may be stated as follows:

1. Beginning with the admission of the patient in the hospital, the injured region is shaved and washed carefully with a neutral solution of oleate of soda.
2. Débridement and épluchage of the wound are practised immediately thereafter.
3. At the same time are installed the Carrel tubes which are introduced to the bottom of the wound in such fashion as to permit the irrigation of the entire wound surface.
4. Application to the entire surroundings of the wound of compresses smeared with vaseline in order to prevent irritation of the skin.
5. Dressing with compresses of absorbent material.
6. After the return of the patient to bed, the Carrel tubes are connected up with the receptacle containing the Dakin solution and irrigation is carried on every two hours, controlled by a simple pressure forceps of Mohr.
7. The dressings are renewed every day and in the course of each one of them, careful lavage of the wound is made with oleate of soda. One must not permit to remain upon the skin about the wound the slightest concretion, for they always hide colonies of microbes.

However, it was not possible for us to judge the method of Carrel at its true value and to derive from it all its benefits until we were able to follow the evolution of the wound by methods of bacteriological control.

This control was a most valuable element in the method of Carrel. It consists in the regular determination of the abundance of the micro-organisms in the wound exudates.

To carry it out there is made a simple smear according to the usual

THE TREATMENT OF WAR WOUNDS

laboratory methods, in which are counted the number of microbes contained in the microscopic field. This bacteriological control was established in a systematic way in our hospital from the beginning of June, 1916. Every two days it was repeated in the same wound. At one time it was being applied in more than 500 patients at a time. For the purpose of being able to follow at a glance the progress of infection in a wound, we have made tracings of the microbic strength. We have made use for this purpose of charts of a special model, resembling temperature charts.

In a general way the microbic curve followed a characteristic line. On the entry of the patient in the hospital or when the wound had just been opened up, the chart indicates in the majority of cases no microbes. At this time the wound is only contaminated, and the infection has not spread over its whole surface. On the second day the chart shows a sharp ascent in the microbic growth and holds itself at high level for some days. In severe infections there may be counted 100, 200, even 1000 microorganisms in a visual field. The line undergoes afterwards more or less oscillations, the progress being more or less downward until the zero point is arrived at after the lapse of a variable time according to the character of the lesion or the nature of the infection.

Sometimes the wound is maintained sterile from the first day, the microbic track following the horizontal line to zero.

The infected wounds were rendered sterile by the Carrel treatment in from six to eight days.

Other solutions recommended for the same purpose gave in general a sterilization more slow and less certain. Certain agents, as flavine, seemed to produce a rapid sterilization in a way more efficient than the Carrel, but generally the results were not stable in their sterilizing power, because they disturbed the granulation of the wound and favored secondary infection.

In the cases of infected fractures the line descended permanently to zero, only after fifteen days to one month. Osseous wounds were sterilized moreover with difficulty. It was the same also with articular wounds. Whenever a sequestrum was present, it was necessary to take it away before definitive sterilization of the wound could be obtained.

The wounds which were soiled and irregular were sterilized more slowly than simple wounds. The *bacillus perfringens* (gas bacillus) and in general all microbes producing gaseous gangrene did not alter the course of the curve. These microorganisms disappeared rapidly from the wound whenever it was freely opened up and freely pared. *Staphylococcus* persisted longer. In cases of *staphylococcus* infection the zero point was arrived at very slowly and very often the infection persisted notwithstanding the treatment.

In fact, bacteriological evolutions in a wound may be considered in three periods:

1. The period of acute infection of variable duration in course of which the microbes are very numerous and present a maximum degree of virulence.

2. The period of attenuated infection during which the curve follows a descending course and corresponds to an attenuation of the microbial virulence.

3. The period of sterilization which is indicated at a line horizontal with zero.

Our collaborator Govaerts has shown that these three periods of microbic infection correspond to three periods in the organic reaction of tissues.

1. During the period of acute infection there are then only polynuclear elements in the wound exudate.

2. In the later course of the microbic disease the polynuclear elements disappear and there are found in the preparation mononuclear elements which become more and more numerous. At the end of this period macrophagi begin to appear.

3. In the course of the period of sterilization there exists in the preparation in the macrophagi.

Evidently, gentlemen, we do not attribute to the microbic curve an absolute value, but in the majority of cases its practical value is the real one, for it permits us to follow the evolution of the infection in the wound and indicates the moment when suture may be practised with the greatest probability of success.

Experience has shown us, nevertheless, that it is necessary to take into account in deciding the moment of suture, not only the quantity of infectious agents present, but their quality and from this point of view was recognized:

1. That wounds slightly or moderately infected by ordinary microbes may be sutured without danger and with every chance of success.

2. That the presence of staphylococci does not contraindicate suture.

3. That the perfringens remain enclosed in the wounds only a very short time, but as long as these microbes do not disappear it was dangerous to resort to suture.

4. That a wound should not be sutured when there was even a slight streptococcic infection.

For the purpose of specifying more exactly the microbic flora of the wound and of determining better the moment most favorable for suture, we have thought it useful to supplement the counting of the microbes upon the smears subjected to bacteriological examination by cultures instituted regularly after the débridement and before the suture. We have to this end adopted a more complete microbic chart, proposed by Doctor Levaditi of the Pasteur Institute, who has devoted himself especially with us to the study of the infection of wounds.

THE TREATMENT OF WAR WOUNDS

The conclusions as to suture up to the present moment have been as follows:

(a) For wounds feebly infected from the first day with ordinary microbes by proceeding to suture when at the second examination the smear yields only one microbe in a visual field.

(b) For wounds strongly infected by ordinary microbes, resort to suture from the moment when the curve came down to one microbe in four fields.

(c) For streptococcic infection never to suture but to submit the wound to adequate treatment, preferably that of Carrel, and to wait until the streptococci had disappeared, or had become attenuated sufficiently to permit primary union.

Streptococcic vaccination may render here the greatest service. The researches made in our hospital by Doctor Levaditi leave no doubt on this point.

Such, gentlemen, are the most important general rules which in our opinion should guide us to-day in the treatment of war wounds, and which have as their object the production of a sterilization of the wound sufficiently complete to make successful suture possible.

Immediate primary suture may be made immediately after débridement or it may be made from two to four days after débridement.

Delayed primary suture, or early secondary suture. In this latter case is done as is primary suture, without refreshing of the wound surfaces by simply approximating the surfaces. Finally, the suture may be made in the course of the granulation of the wound when sterilization has been sufficiently assured.

Secondary suture. This always necessitates the refreshing of the wound surfaces by which step it is distinguished from the preceding methods of suture.

The immediate suture is indicated in cases where the clinical aspect of the wound after débridement and épluchage gives a guarantee of sufficient sterilization. It may be resorted to especially:

1. In wounds of joints, and in general, in wounds of serous cavities.
2. In wounds of the cranium, of the face, of the hand and of the foot, where the abundance of vascularization, both blood and lymph, warrants a surgeon in making immediate suture as a rule.
3. In superficial wounds of the soft tissues in certain fractures without comminution. This suture has the advantage of offering anatomical repair of the tissues, but infections, when they take place, are always rapid and grave, involving diffuse phlegmonous and gaseous gangrene.

Late primary suture or early secondary is indicated particularly for wounds involving soft tissues only and for some open fractures. It is done after bacteriological control has been made as described above. Late primary suture rarely fails of success on account of grave accidents.

Late secondary suture is reserved for wounds which can not be sutured

during the first days, because of too extensive destruction of tissue, or because of the development of infection. It offers the great advantage of giving complete security, but it delays the healing and does not always give as perfect an anatomical restitution as the other forms of suture.

There remains now for examination the problem of the treatment of war wounds from more special points of view, and of considering the peculiarities which arise from the organ or the tissue wounded.

We shall examine in succession:

Wounds of the cranium.

Wounds of the face, of the hands and the foot.

Wounds of the soft tissues.

Amputation stump wounds. Fractures.

Joint wounds.

Wounds of the chest.

Abdominal wounds.

We shall limit our discussion to general indications.

Wounds of the Cranium and of the Hairy Scalp.—When we have to deal with a wound of the hairy scalp, limited to the soft parts, we cut away the margins of the contused surface and suture them immediately. When the cranium is wounded without an opening in the meninges, we practice regularly trephining in order to take away the fragments in the internal table which are practically always present and, as in the case of wounds involving only the hairy scalp, we finish with immediate suture.

When a wound of the brain has taken place two complications are feared: 1. Cerebral hernia. 2. Meningo-encephalitis, that is to say, infection of the meningo-encephalic spaces.

The hernia is the result of the œdematous and blood congestion of the cerebral substances during the first hours which follow the traumatism. It corresponds to the swelling of the external features in wounds of the face, but with this special feature that encephalic congestion drives to some degree the cerebral contents out from the cranial-box. Once established, the cerebral hernia invites infection and favors its development by the spaces which are created beneath it and which it is impossible to keep aseptic. We find ourselves then always in the presence of a vicious circle, the continuity of which it is often difficult to break.

Therefore, in treating a wound infection the surgeon should always seek to hinder the production of the hernia. Dressings which produce compression are from this point of view indispensable above all on the first days.

The ideal treatment consists without doubt of disinfection at a single sitting of all cerebral lesion and in immediate closure of the wound, but the experience at our hospital has been that wounds of the brain are contaminated or infected by the projectile in the proportion of 55 to 60 per cent., and that it is not possible to render them sufficiently aseptic at

a single seance by any means at our disposal. Therefore, the immediate closure of the cranial breach has been attended with danger in a number of cases.

In determining the course it is necessary to be guided by the microbic curve and to resort either to late primary suture or to early secondary, or to secondary suture more or less late, if a sterilization is more or less late in being accomplished.

Wounds of the face have this in particular, that they involve vascular regions not favorable to the development of gaseous gangrene and to infection in general, they may with all certainty be brought together by immediate suture in most cases. Moreover, the retractions which inevitably follow in a wound of the face left open for a certain time often prevent apposition of the skin when a secondary suture is made and produce deformities more or less marked. It is then a matter of importance to close wounds of the face as early as possible.

When the lesion is superficial and the soft tissues alone are involved, cutaneous flaps may be formed and the suture definitely accomplished at the same seance. Complicating fractures of the jaw do not constitute an obstacle to the immediate suture. The specialist may generally succeed in manipulating through the reconstituted buccal cavity the prothetic apparatus which is necessary to hold the fragments in coaptation. If the mass of the face is widely destroyed, the skin should be brought over it as far as possible so as to prevent retraction, and æsthetic repair of the face should be accomplished later by rhinoplasty, cheiloplasty, or other autoplasic processes.

Wounds of the Hand and of the Foot.—It is important here, likewise, to suture the wounds as early as possible in order to prevent retractions and to lessen the losses of functional power which may follow. But though immediate reunion may practically be possible in all superficial wounds where they are limited to the hand and to the foot, it is not always so when the destructions of tissue have been great. Infection in these cases is often difficult to overcome because of the multiplicity of the cellular spaces and the complexity of the joint cavities which often connect with each other. To secure their sterilization it is necessary to widely open the wound throughout its whole extent, and for this purpose resection and wide arthrotomies are often indispensable.

We have operated during the period from June, 1916, to November, 1917, on 523 wounds of head, face, foot and hand which have resulted as follows:

- (a) 491 Immediate sutures which have given:
 - 473 Complete successes, *viz.* 96.3 per cent.
 - 8 Partial successes, *viz.* 1.6 per cent.
 - 10 Failures, *viz.* 2.1 per cent.
- (b) 18 Late primary sutures which have given:
 - 18 Complete successes, *viz.* 100 per cent.

(c) 64 Secondary sutures which have given:	
58 Complete successes, <i>viz.</i>	90.6 per cent.
4 Partial successes, <i>viz.</i>	6.2 per cent.
2 Failures, <i>viz.</i>	3.2 per cent.

Wounds of the Soft Tissues.—Superficial wounds of the soft tissues lend themselves generally well to immediate suture, and according to the more or less large extent with which the processes of débridement and épluchage have been resorted to we may determine the indications of the wounds in a large measure. It would be dangerous, however, to go to too great an extent in this direction, for immediate suture does not permit any bacteriological control, and very often the perfringens bacillus and the streptococcus are there, only awaiting a favorable occasion for their development.

One should not lose sight of the fact that in delaying the suture in order to permit of a preliminary bacteriological examination one does not practically prevent the healing. If, in fact, the wound is sterile at the beginning, the microbic test will show it and one can practice the late primary suture on the second, third, or fourth day, with every certainty of success. If, on the contrary, infection persists after the débridement and the épluchage of the wound, it has been to the interest of the wounded man that the microbic curve has been established and that the suture should be done secondarily after sufficient sterilization.

However, it may be accepted as a general rule that primary suture of a wound should not be the rule:

(a) When the lesion dates back more than eight hours.

(b) When the patient has been already subjected to previous surgical examination.

(c) When the lesions involve deeply the muscular masses and when the tissues are much soiled and lacerated.

As we have seen, secondary suture is done by bringing the margins together after refreshing and removal of the cicatricial film. The granulations are left in place; they do not hinder the union by first intention.

When the wound is irregular, in certain cases the irregularities may be overcome by dissecting the granulations without and within, so as to turn them over upon themselves. Moreover, the muscles may be dissected and sutured to their fellows. Care should always be taken to suture the aponeuroses in order to prevent later muscular hernias. If very strong tension of the skin is present, it is necessary to make more or less extensive slidings thereof. Sometimes one must proceed to a cutaneous débridement. Quite often we have had recourse to grafts after the Italian method, or to epidermic grafts, or often to the "greffe en culbute," which consists in cutting the cutaneous flap at a distance more or less great from the wound and bringing it to the wound by successive steps, turning it over upon itself.

THE TREATMENT OF WAR WOUNDS

The number of wounds of the soft tissues which have been treated during the period from the month of June, 1916, to the month of November, 1917, has been 1447, the outcome of which has been as follows:

- (a) 380 Immediate sutures with:
 - 317 Complete successes, *viz.* 83.9 per cent.
 - 24 Partial successes, *viz.* 6.3 per cent.
 - 39 Failures, *viz.* 29.8 per cent.
- (b) 222 Late primary sutures with:
 - 207 Complete successes, *viz.* 93.2 per cent.
 - 8 Partial successes, *viz.* 3.6 per cent.
 - 7 Failures, *viz.* 3.2 per cent.
- (c) 845 Secondary sutures with:
 - 724 Complete Successes, *viz.* 85.6 per cent.
 - 70 Partial successes, *viz.* 8 per cent.
 - 51 Failures, *viz.* 6.4 per cent.

Amputation Stump Wounds.—When a surgeon amputates a limb, he should never forget that the stump is to support later an artificial limb. This idea is so often lost sight of in the course of amputations that I feel that I should insist upon its importance. The surgeon uses all his skill in fashioning a fine flap which carries the suture line upon the side, but he takes no account of the length of the arm for leverage to which an apparatus may be fitted. The immediate operative result occupies his mind only, while he leaves to the orthopædist the care of the prothesis without troubling himself with the importance that he should furnish to the latter a stump easy to equip.

It is, nevertheless, proper to remark that formerly the bearing of prosthetic appliances was at the end of the stump, and that therefore a lateral scar had its reason for being, but most modern apparatuses take their point of bearing over the whole surface of the stump and leave the extremity free from any contact whatever. The result is that the apparatus now used are more appropriate for a terminal cicatrix than for a lateral cicatrix, and that they may often be put in place before cicatrization is entirely completed. Adherent scars when they are terminal do not otherwise constitute an obstacle to the prothesis, and in making the decision it is always the length of the arm of the lever which should take precedence over the qualities of the cicatrix.

From another standpoint we formulate three essential considerations which should cause us to reject primary suture in a great number of cases of amputations for war wounds.

(a) It is necessary to act quickly and to seek first, above all, to save the wounded man's life.

(b) Primary union is difficult to secure. The stump wound being generally infected, its immediate closure is sure to produce great complications.

(c) It is necessary to amputate as low as possible, often through a traumatized area, in order to leave the bone as long as possible.

Guillotine amputations are from this point of view the most favorable. They give, after repair of the stump, a lever arm longer than amputations after primary suture with a flap, the fact being that such suture rarely succeeds and if done it is necessary to intervene a second time.

We have made since June, 1916, to November, 1917, 31 secondary sutures after amputation which have given 26 complete successes, 4 partial successes, and 1 failure.

Open Fractures of the Long Bones.—The objective toward which we direct the surgical treatment of open fractures apart from the orthopædic treatment, is the transformation of an open fracture into a closed fracture. To this end:

(a) Musket-ball fractures with through and through wounds, with small orifice of entry and of exit, without swelling and without lesion of the great blood-vessels, are treated aseptically and are simply immobilized in an apparatus with extension. The patient is watched closely for the first week and if accidents of infection develop, the fracture is operated upon.

(b) Other fractures are operated upon at once. The wound is opened up by an incision sufficiently wide to permit of a deep exploration of the entire wound area surrounding the fracture; at the same time excision of the lacerated soft parts and extraction of foreign bodies is accomplished. Free bony fragments are taken away with care, pointed bone ends which threaten the vessels and the nerves are resected, but care should be taken to preserve as far as possible a bony bridge between the fragments in order to favor consolidation.

The wound is then sutured immediately either by late primary suture or by secondary suture according to the seat and extension of the lesion and the gravity of the infection.

Immediate suture is attended only in cases very exceptional which present a minimum of soft tissue, as the humerus and forearm. It is never practised in the course of an offensive and is contraindicated in wounds of the soft tissues when the wound dates back more than eight hours, or if a wound can not be kept under the same surgical oversight.

Primary delayed suture or early secondary suture is practised when the microbic curve present shows a sufficient sterilization from the beginning of the treatment.

Late secondary suture is the most frequently resorted to. It may be used as soon as the Carrel treatment has obtained the clinical sterilization of the lesion, that is to say, from fifteen days to a month, unless the infection has been due to streptococci. In the event of this last accident, suture may be delayed for several months.

The treatment which we have just sketched and which consists in transforming the open fracture into the closed fracture shortens much the time necessary for cure and guards the patient from the complications produced by prolonged immobilization.

THE TREATMENT OF WAR WOUNDS

We resort to amputation in case of fracture only in extreme cases. Experience has shown us that one can by careful application of the method of Carrel preserve limbs which in former times would have been considered irremediably lost.

The number of fractures operated in our service from May, 1916, to November, 1917, has been 191, divided as follows:

(a) Fractures of the femur, 43, of which there were 4 primary sutures with 4 cures, *viz.*, 100 per cent.

Under delayed primary suture

39 Secondary sutures which gave:	
30 Complete cures, <i>viz.</i>	76.9 per cent.
7 Partial successes, <i>viz.</i>	17.9 per cent.
2 Failures, <i>viz.</i>	5.2 per cent.

(b) Fractures of other bones: 148.

26 Primary sutures with:	
20 Complete cures, <i>viz.</i>	76.9 per cent.
3 Partial successes, <i>viz.</i>	11.4 per cent.
3 Failures, <i>viz.</i>	11.34 per cent.

20 Delayed primary sutures with:

16 Complete successes, <i>viz.</i>	80 per cent.
4 Partial successes, <i>viz.</i>	20 per cent.

102 Secondary sutures with:

92 Complete successes, <i>viz.</i>	90 per cent.
3 Partial successes, <i>viz.</i>	3 per cent.
7 Failures, <i>viz.</i>	7 per cent.

Joint Wounds.—Under the head of joint wounds, we simply include those of the large joints, as of the knee, of the hip, of the elbow, and of the shoulders. In general, an articulation kept open becomes infected notwithstanding the most daily care. On the other hand, the immobilization to which the limb is subjected added, to the constant irritation of the joint surfaces by the secretions with which they are bathed determines the presence of adhesions and ankyloses.

During the first period extending from December 20, 1914, to September 10, 1915, we treated joint wounds by the system then in use everywhere, which consisted in the drainage of the cavity, the dressings being renewed several times a day at each of the dressings to irrigate with an antiseptic solution, such as oxygenated water, formalin water, carbolated water, etc. The limb was immobilized either by means of an interrupted apparatus (bridged) or by means of a gutter. The results were frankly bad. At this time the wounds of the knee-joint were considered as the gravest in character in war surgery.

During a second period, extending from December 10, 1915, to July 1, 1916, we applied the method of Carrel after débridement of the wound. The results were a distinct improvement over those of the first period,

but they were still not very brilliant. They demonstrated to us, especially for the knee, that the method of Carrel was not sufficient to make certain in a dependable manner the practical sterilization of a joint cavity.

Since the month of July, 1916, we have resorted to wide arthrotomies with immediate closure of the joint whenever possible.

From the month of May, 1916, to the month of November, 1917, we made:

(a) Sixty-six immediate sutures for wounds of the large joints without bony lesion. Of these there were 62 cures, *viz.*, 95.7 per cent.; 4 failures, *viz.*, 6.1 per cent.

(b) Seventy-nine immediate sutures for wounds of the large joints, with bony lesions. Of these there were 71 complete successes, *viz.*, 89.8 per cent.; 1 partial success, *viz.*, 1.2 per cent.; 7 failures, *viz.*, 7.0 per cent.

These results show indisputably the superiority of immediate suture after wide arthrotomy, closing of the joint cavity, over any other method of treatment. It is necessary, however, not to lose sight of the fact that conditions do not always favor a primary suture at the elbow and at the shoulder. In wounds of these regions, in fact, the soft tissues are often so torn that it is impossible in many cases to secure apposition in the wound borders. The Carrel treatment followed by secondary suture or by cicatrization by second intention is evidently indicated in such cases.

On the other hand, the results of resections are not the same for the elbow and the shoulder joints, as for the knee-joint. In the two first, resection results in articular mobility, while in resecting the knee the movements of the joint are in great measure destroyed. Therefore, for the shoulder and the elbow, one easily decides to do a resection, when one shuns it at all hazards in cases involved in the knee. Aside from cases in which there was a simple through and through wound with minute orifices which healed spontaneously, the treatment of choice of numerous war wounds involving a joint consists in a wide opening of the joint, a careful cleansing of the cavity, curettage of the osseous surfaces, if they are injured, and the immediate suture of the wound, with or without drainage. Immobilization is *de rigueur* from six to eight days.

The Carrel treatment is indicated in joint wounds with extensive lesions of the soft tissues which do not allow approximation of the skin, which is often the case at the elbow and at the shoulder. However, in these cases the attempt may be made to close the fracture primarily by means of a sliding of skin or by an autoplasty. Finally, a resection is justified in extensive lesions of the bony ends, but it is necessary not to lose sight that typical resection, particularly at the elbow and at the shoulder, promise better results from the point of view of function than an uncomplete operation leaving an osseous callus at the lower part of the articular cavity.

There remain, then, two questions for consideration with regard to joint wounds:

THE TREATMENT OF WAR WOUNDS

(1) When a purulent infection of an articulation has taken place, how should it be treated?

(2) Joint resection having been judged necessary, is it necessary to follow it with primary suture, or is it better to resort to secondary suture?

(1) The first question has been answered by Doctor Willems who, cutting loose from ancient prejudices, has replaced immobilization by active mobilization. The movements to which a joint is subjected when they are executed by the patient are not painful, and the results produced by this mode of treatment are really remarkable. The suppuration diminishes rapidly and infection disappears and the joint mobility is preserved, even when infection has been profound, with relatively considerable tissue destruction. It is proper to remark, however, that the mobility can give its full return only when its application is watched over by a competent surgeon.

(2) As to whether it is better after articular resection for a war wound to make primary suture or secondary suture, the conditions will vary according to the joint affected. For the elbow and the shoulder, as a rule, it is better to make immediate suture for the end of preserving movement, but as our experience has demonstrated, such a result can rarely be realized. In a large number of cases we have had to resort to secondary suture, or often to permit the wound to heal by secondary intervention.

After resections of the hip and especially after those of the knee, primary suture is dangerous. On account of the impending infection, it is better to leave the wound open, to keep the bony surfaces separated by apparatus, to sterilize the wound according to the method of Carrel and to complete the surgical treatment by secondary suture.

Chest Wounds.—Taking up next the question of the closure of penetrating wounds of the chest, that is to say, open pneumothorax. When the thorax is opened, the air rushes into the pleural cavity and the lung contracts upon itself with the result that there is a disturbance of the respiratory equilibrium which may go on even to asphyxia, syncope, and finally death. Generally, however, the respiration becomes reestablished and regular after a certain time through the coöperation of the lung on the sound side. The lung on the wounded side remains contracted in a state of collapse; after a time it loses its elasticity and becomes fixed after a fashion in its new position.

As the result of the inflammatory reaction of the pleura, there is formed a fibrinous layer more or less thick, which encloses the lung and is the source of the impossibility of the lung undergoing physiological expansion. There is thus established between the lung and the parietes a separate cavity which necessarily persists as long as the lung can not be brought into apposition with the thoracic wall. In order to accomplish this have been advised the operations of Estlander, of Schede, of Delorme, and the one which we ourselves have recommended to depress the wall of the thorax by a massive resection of the costal wall.

The general considerations that we have just stated show how important it is to close the thorax immediately after the wounding. The rules which have been adopted by us at our hospital are based essentially upon the idea of securing the suture of the parietes. They are as follows:

(1) If the thorax is widely opened and the lesions recent, and there is persistent hemorrhage from the lung, the indication is to apply hæmostatic suture to that organ, although if the flow of blood is very abundant and the condition of the wounded man is very threatening a tamponade of the pulmonary wound must be resorted to. In order to close the pleural cavity if it is not possible to close the thorax breach by reason of its extent or because of the menace of infection, we apply a special tampon that we have designed which we call "*tamponnement en bouton de chemise*" (shirt button tampon), which makes certain the hermetic sealing of the cavity at the same time that it permits drainage.

The use of local anæsthesia in the course of intervention and in the later dressings is most useful.

(2) If the orifice is narrow but still permits the air to enter, it is necessary as soon as possible to obtain its secure closure in order to stop the progress of the pneumothorax. It should be well understood, however, that, in cases of hemorrhage of the lung a preliminary enlargement of the pleural opening may be necessary in order to treat the pulmonary wound. Occlusion of the thoracic wall is accomplished by the suture *en masse* of the musculocutaneous planes.

(3) If there is present an open pneumothorax, with an already developed pleural infection, the treatment of Carrel is instituted in all cases and as soon as sterilization of the wound has been accomplished the cavity is closed by suture in the musculocutaneous spaces.

Before proceeding to closure it is indispensable to control the sterilization of the pleura by cultures from the exudate. It is necessary, moreover, that the pleural secretion should have become completely dried up. It is only in these conditions that operation may have any chance of success and that it will replace definitively all those methods of intervention, which in order to bring the lung and the parietes into apposition demand more or less resections of the costal wall.

Wounds of the Abdomen.—In order to complete our report, we should now speak of suture of the wounds of the abdomen, but such general accord has been established that all surgeons think that early intervention should be resorted to. For the end of permitting us to intervene as early as possible in abdominal lesions; lesions of the thorax or in cases of severe hemorrhage we established at a distance of 2 or 3 kilometres from the front, advanced dressing stations sufficiently well equipped to make possible interventions of urgency. The installation of these posts reduced the mortality in wounds of the abdomen from 65 per cent. to 45 per cent.

THE TREATMENT OF BURNS

AS EXEMPLIFIED IN THIRTY-TWO CASES

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THE function of this paper is not to give any new or original ideas in the treatment of burns, but rather to set forth our opinion of comparative values of well-known methods of treatment gained from the experience of simultaneously treating 32 cases of severe, extensive, multiple burns of varying degree. During this period we had the opportunity of watching the comparative values of antiseptics, wet and dry dressings, non-interference by leaving the burned area severely alone, open and closed treatment, air, sunlight, and electric light, protectants, such as paraffin and ointments, tissue stimulants, such as balsam of Peru, and surgical assistance, such as skin grafting, burns of apparently the same degree, received under the same conditions, and treated by the same staff of attendants.

The type and method by which the injuries were received may be gained from the following brief history. While coaling a ship a sudden coal dust explosion occurred, shooting a solid sheet of flame through coal bunkers, passage-ways and hatches, enveloping all occupants with an almost complete covering of fire. All the men injured had been coaling ship for several hours and were covered with the usual amount of perspiration, coal dust and dirt, which accumulates during a hard day's work handling coal. Immediately following the injury all men were taken to the ship's hospital, severe cases given morphine sulphate gr. $\frac{1}{4}$ hypodermically and all burns given an emergency dressing of aqueous solution of picric acid. Patients were then wrapped in blankets and preparations made for transportation to hospital ashore. This necessitated an outdoor exposure of about fifteen minutes, during which time all patients were carefully and fully wrapped in four to five heavy blankets on a warm day.

Patients were received in previously prepared and warmed beds. Great care was executed in transferring patients from stretchers direct to bed. Immediate application of external heat and general measures to prevent and minimize shock at once resorted to. A survey of all cases revealed the following general conditions: All faces were badly burned, swollen beyond recognition, with a mass of blebs, coal dust and dirt. Fig. 1 gives a fair example. The severer cases had large multiple areas of burn covering practically the entire surface of the body. All surfaces heavily laden with coal dust. All patients were in considerable pain.

All complained bitterly of being chilled. Practically all cases commenced to show some evidences of beginning shock.

Our initial treatment was quickly instituted as follows: External heat and body protection was generously provided. Morphine sulphate gr. $\frac{1}{4}$ repeated if necessary to severe cases. Continuous proctoclysis of normal salt with sodium bicarbonate given to severe cases. It is difficult to draw an adequate picture of this initial appearance. Practically all the faces were a mass of blebs, dirt and burn, accompanied by enormous oedema, closing the eyes tightly and obliterating the usual margins of lips, chin and neck. Our next immediate step was to remove some of the emergency dressings. To all faces we applied a generous smear of boric acid ointment. Gently pried open the eyelids and instilled liquid petrolatum. Areas on the body and extremities having a well fitting dressing, we temporarily allowed to remain, other dressings were carefully removed and a wet dressing of 1 per cent. aqueous picric acid solution applied, patients made comfortable and our efforts directed toward general measures.

The afternoon of admission two cases died—both very extensively and severely burned. Twelve hours following admission three more cases died. These cases, fully two-thirds of body area having been burned, coupled with considerable smoke and fire inhalation. None of them rallied from initial shock—coma and delirium gradually deepening until death.

Twenty-four to thirty-six hours later we had four more deaths. These patients rallied from initial shock only to pass quickly into a secondary depression with suppression of urine, coma and death. Careful use of morphine and continuous rectal drip with salt and sodium bicarbonate, although retained and absorbed in large amounts, seemed of no avail. All the fatal cases ran about the same course, coma, delirium of low type, suppression of urine and temperature rise of 104° F. and 105° F.—in two cases, 106° F.

We lost one other case, a patient, Fig. 2, taken third week, very severely burned on face, neck, entire chest, and back, small area on abdomen, both hands, forearms and legs. Following a stormy and precarious condition, during which period for days we expected a fatal ending, the patient rallied, almost completely recovering from all burns only to be followed by a bronchopneumonia to which patient succumbed on the thirty-seventh day. This case and case number one, also very severely burned, we considered our success, due to the continuous judicious use of morphine in an effort to lessen absorption, and the continuous use of the rectal drip, adding 4 per cent. glucose to our alkaline solutions, which fortunately the patients retained well and absorbed in large quantities.

To recapitulate briefly our general measures:

1. Morphine sulphate on admission to patients in great pain. Later to severe cases, in two of which we attribute in great part their recovery to its

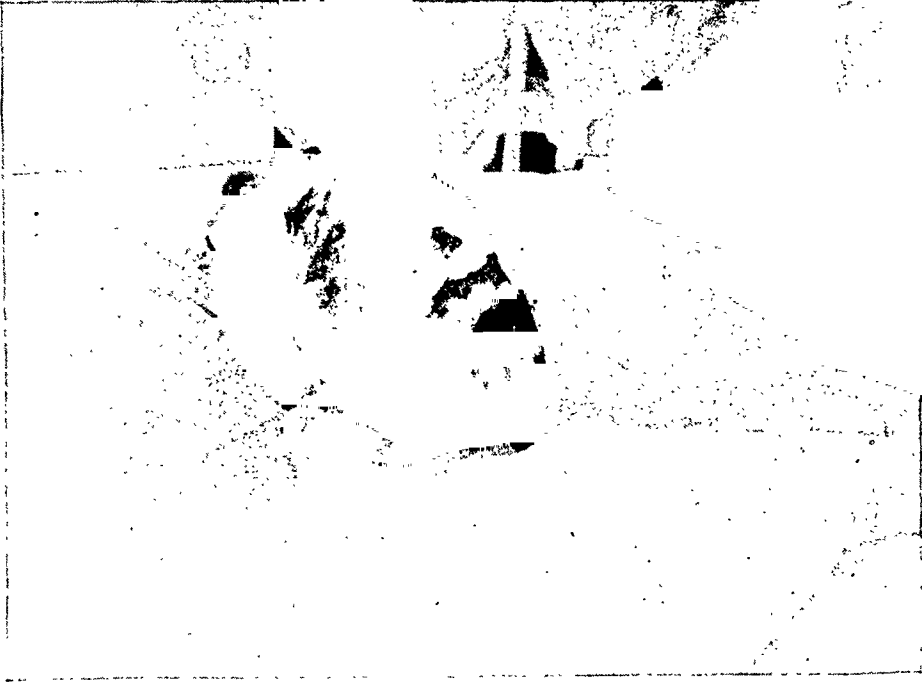


FIG. 1.—Taken on seventh day. Typical initial picture of all faces.



FIG. 2.—Burned on face, neck, entire chest, and back, small area on abdomen, both hands, forearms, and legs.

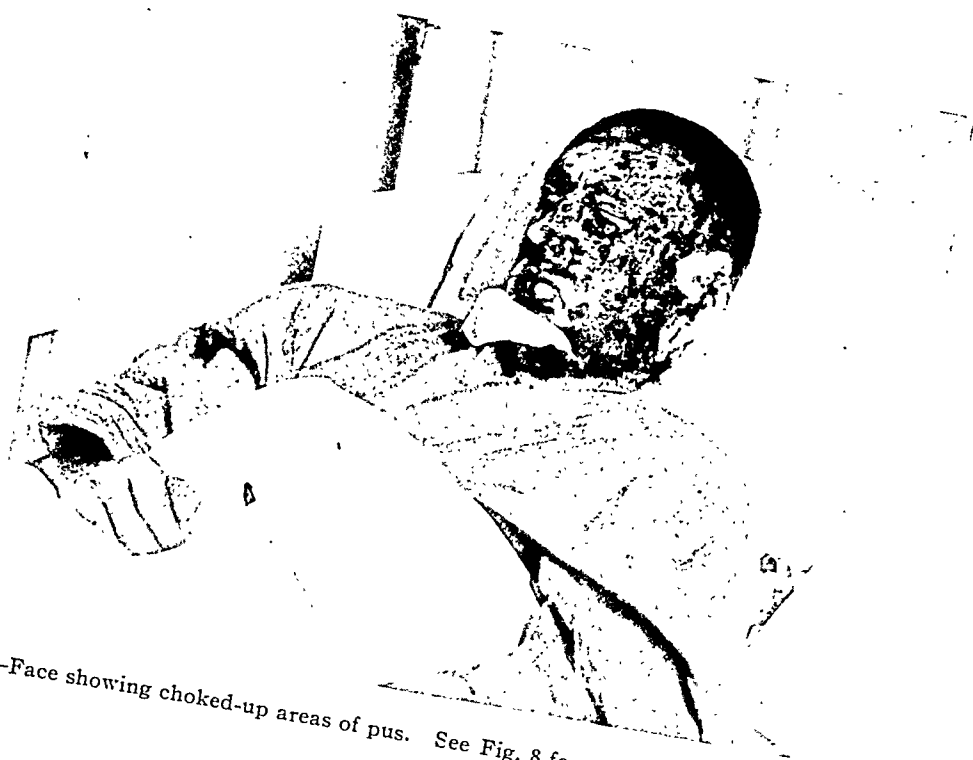


FIG. 3.—Face showing choked-up areas of pus. See Fig. 8 for same patient four weeks later.



FIG. 4.—Entire face cleared except dry elevated patch $\frac{1}{2}$ -inch high with skin healing arrested beneath.



FIG. 5.—Showing heaped up areas of excrustation. Dry elevation $\frac{1}{4}$ to $\frac{1}{2}$ inch with skin healing arrested beneath.



FIG. 6.—Same pathology as Figs. 4 and 5 on face.



FIG. 7.



FIG. 8.—Same patient as Fig. 3. Entire face and hand healed with no scarring.



FIG. 9.—Typical example of results.

THE TREATMENT OF BURNS

use. These patients we maintained under morphine continuously for a period of two weeks, gr. $\frac{1}{8}$ night and morning. This amount held patient quiet, comfortable and, we believe, greatly reduced absorption, which at that time was constantly taking place in large quantities, from wide areas of deeply burned, sloughing and infected tissue.

2. Continuous use of normal salt, sodii bicarbonas and 4 per cent. to 8 per cent. glucose by rectum.

3. Large quantities of liquids every two hours by mouth. Milk, egg-nogs, soups, water during the day, and from two to three egg-nogs with the addition of small amounts of whiskey during the night.

4. Later during the fourth and fifth week, when the element of exhaustion, together with the weakening effects of daily dressings, commenced to play an important rôle in Cases I and II, we added to our supportive measures a tonic of phosphorus, strychnine and quinine, to which both patients responded well.

The second day we commenced our local treatment of burned areas. To the faces we applied a light coat of sterile boric acid ointment. Figs. 1 and 3 represent a fair picture of the appearance of all faces at the end of the first week. At this period our method of treatment looked far from encouraging. We had large, swollen, unrecognizable masses, with heaped-up areas of incrustation, beneath which were choked up large quantities of pus. (Fig. 3, yellow areas represent small pockets of excretion beneath brown crusts.)

At this stage it seemed reasonable to assume that gentle removal of these loose crusts, literally floating bodies upon this choked-up pus, would give complete drainage and rapid healing would follow. We divided our cases, in some pursuing the policy of gentle removal of loose crusts, in others we followed the policy of strict non-interference. The pathology proved to be most puzzling and the healing one of the interesting conditions in our series.

In all cases, our carefully picking up these loose, floating crusts with gentle evacuation of exudate was invariably followed by a repetition of the same process, time and time again. The control cases (Figs. 1 and 2) in which the policy of severe non-interference was pursued, looked equally as bad. We continued both lines of treatment. Gradually the non-removal cases slowly cleared with the exception of small areas of large heaped-up incrustations on foreheads, around ears and necks (Figs. 4, 5 and 6) which remained apparently dry and pus free beneath but continued to slowly increase in elevation. Our interference cases continued to excrete and crust up generously over all areas. We then applied the non-interference procedure to them, our results were the same, a slow cleaning up with the exception of isolated areas (Figs. 7 and 8) with enormously heaped-up incrustations. These local areas slowly filled with exudate and it was deemed advisable to remove them when this could be accomplished without any force, but by merely lifting away the loose area,

it was removed. A few days later the old condition reappeared. Removal in due time was again followed by reappearance. There being no heaping up of granulation tissue beneath these patches, and as the areas were small, the patients, some of them, up and around with nice healing over all surfaces, we again adopted a policy of non-interference, believing that in time the skin surface would bridge over and the areas heal. A few weeks experience taught us the following: There seemed to be two separate, distinct periods, at which time, two distinct results occurred, simultaneously, in all cases. The first period in which removal was continuously followed by the same exudative heaping up process. The second period in which following a week's period of non-interference, removal, at this juncture, of the crust with the application of a thin smear of boric acid ointment on lint was followed by a quick bridging over of the raw surface with new skin and complete healing with no scar formation in a few days' time. Following this procedure we finally obtained complete healing, with new skin formation and no contracture, no eversion of eyelids and no disfigurement in our entire series. Figs. 8 and 9. (Figs. 8 and 3, same patient four weeks interval.)

To body surfaces and extremities we instituted a variety of treatment. At the outset two general procedures were decided upon. First, a system of more or less non-interference, with the application of some wet antiseptic dressing in which at daily dressings the strictly loose, free pieces of dead skin were carefully and gently picked away, and no effort made in any way to clean up the surface, every effort being expended to minimize to the utmost, traumatism to the part. The second system of moderate interference in which open, punctured blebs were picked up, the skin carefully snipped away and an effort made to more or less clean up the area.

We believe without question that the less encouraging the burned surface appears during the initial dressings, as far as to macroscopic appearance of dirt, irregularity of surface due to semi-adherent folds of dead skin, etc., the better will be the ultimate result, providing, of course, continuous effort is pursued to clean up any infection present. Our experience also demonstrates the individual value of different applications applied to different type lesions and the great significance of applying the proper dressing to individual type lesions at the proper time. As evidence of this, we received tremendous healing with new skin promotion by the use of wax dressings in some cases, whereas in others, of apparently the same type of lesions, this form of dressing had to be discontinued and our results were obtained by protection with ointment spread on lint with paper strips, or rubber tissue.

Our treatment after the initial relief of pain, obtained by picric acid dressing, may be broadly divided into two great stages. First the cleaning up stage, in which antiseptics were used to clean up the tremendous amount of infection present, and second the protection stage in which the

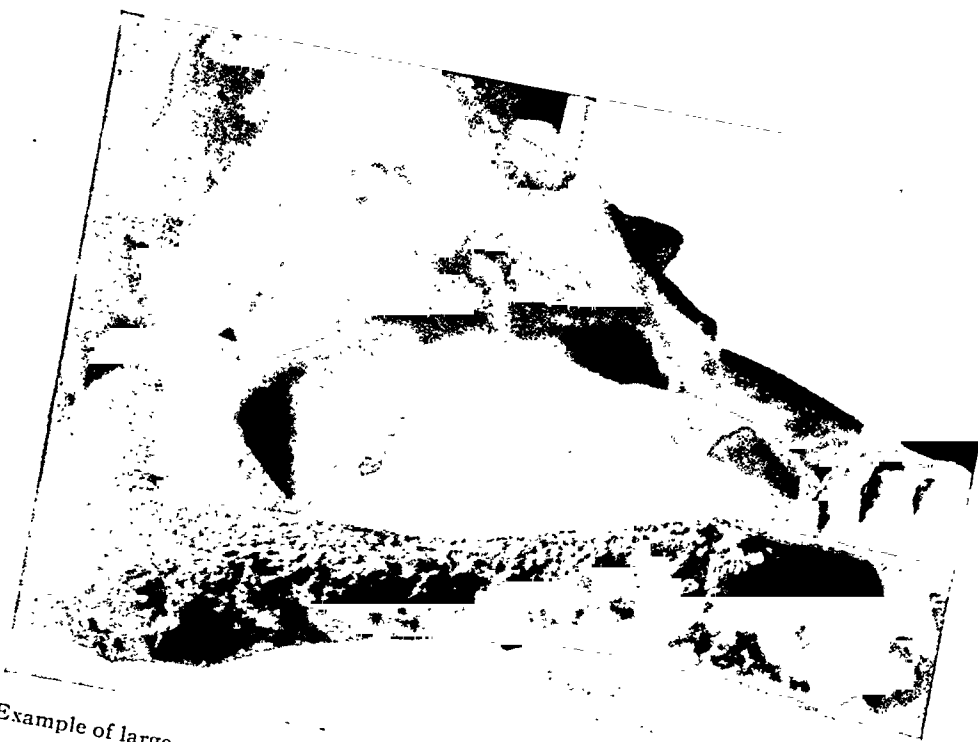


FIG. 10.—Example of large areas of deeply infected tissue from which tremendous absorption takes place.

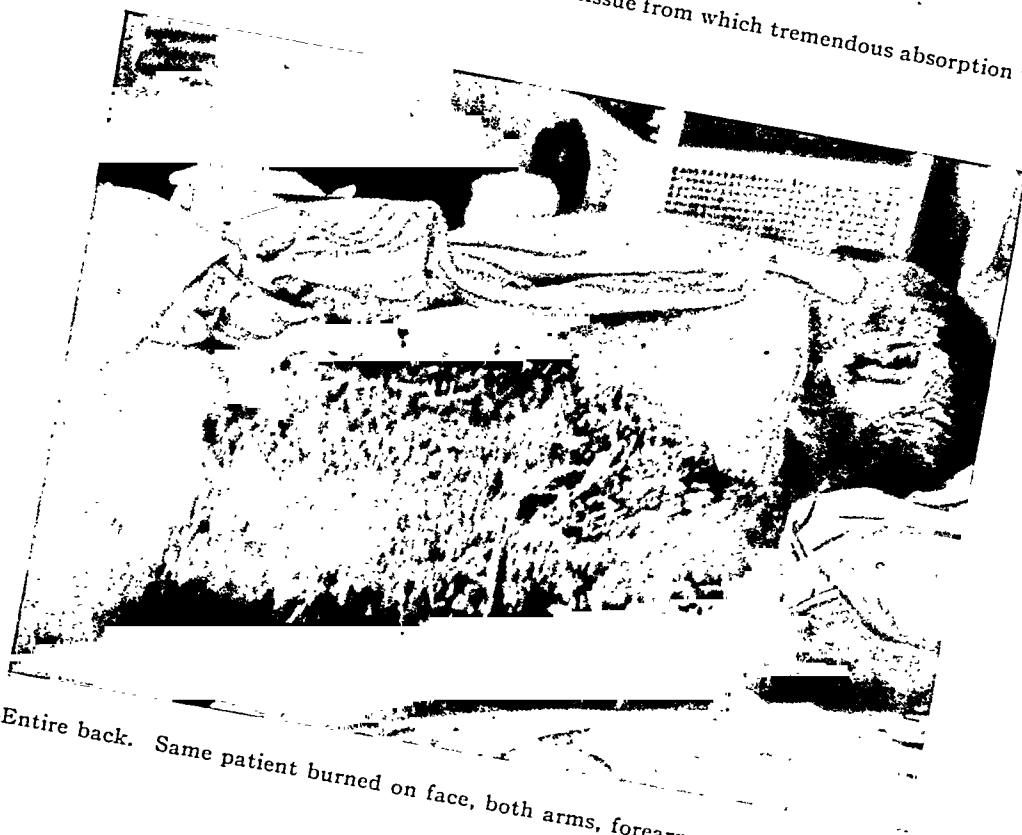


FIG. 11.—Entire back. Same patient burned on face, both arms, forearms, hands and entire right leg.



FIG. 12.—Shoulder and buttocks.



FIG. 13.—Example of extent of burn on arms.



FIG. 14.—Large areas showing results obtained.

THE TREATMENT OF BURNS

area was carefully protected and nature encouraged to do her part with as much assistance by us as possible, in line with a minimum amount of interference. In the first stage of our non-interference cases we applied wet dressings of dilute alcohol, boric acid solution or normal salt solution. After an initial antiseptic treatment a system of exposure to open air was instituted. This was followed in due course by a simple protection, boric acid ointment on lint or paraffin, and the area rapidly healed. Large body surfaces, such as chest and back, to which the application of wet dressings was impracticable, we applied boric ointment to in thin films, bathed the surface with liquid petrolatum or used paraffin, depending upon the ease with which the patient was able to be dressed, the amount of exposure he tolerated and the amount of damage rendered in removing the type of dressing applied. Liquid petrolatum and paraffin we found very serviceable, but also discovered that each served a well-defined period, after which its usefulness seemed to be impaired, and a change to some other protection, rapidly stimulated skin formation and the area quickly healed. In the large majority of our cases these simple procedures gave excellent results. In the second series of what we will term interference cases, our results were vastly different. Our interference in these cases consisted of gently picking up loose or very easily removable areas of apparently dead tissue. Following this, the cases were given open exposure. During the first week these cases appeared to be far in advance of all others, the areas appeared clean, redundant tissues had all been removed, and apparently healing would quickly follow. We were doomed to disappointment. We soon discovered that the areas were all deeply infected and the cleaning up process was proved to be a slow and difficult one.

We first applied wet dressings of boric acid solution, weak alcohol, or salt solution, depending upon the area, the irritability of patient, his resistance to dressing manipulation and "how the area looked." Some of our cases (Figs. 10, 11, 12, and 13) presented large areas of deeply infected tissue in which, as the patient's general condition gave evidence, the element of absorption, irritation and manipulation exhaustion, was a serious one. To these parts we tried the following procedures—open air, exposure to electric light, boric ointment, liquid petrolatum, paraffin, wet dressings and continuous irrigation.

The following procedures proved most valuable and for stated periods gave the best results: Continuous irrigation with Wright's solution (hypertonic salt), Dakin's solution, normal salt solution, and a modified Dakin's solution (quinine sulphate, 8.00 grammes; hydrochloric acid, 4.00; acetic acid, 40.00; sodium chloride, 140.00; formal (40 per cent.), 8.00; thymol, 2.00; alcohol, 120.00, and equa q.s. for 8000.00 mils) were equally efficacious for their respective periods. It was found that the area cleaned beautifully with Dakin's solution up to a certain period, after which irritation took place and it was then necessary to substitute normal salt

solution for the remainder of the period, this in turn being followed as soon as possible by protection only, given by the application of paraffin or boric acid ointment on a moderately stiff backed dressing—we used lint.

Wright's solution was deemed efficacious in one case in which considerable absorption was going on. Its application to these greatly swollen, raw, infected areas produced a distinct exosmosis, throwing out huge quantities of serum, which aided considerably in allowing nature to overcome the infection. Our method was to apply loose wrinkled gauze over the area and continuously keep this moist, either by a continuous drip arrangement or by periodic applications of solution. Entire dressing was removed and reapplied once in twenty-four hours.

As soon as the area appeared fairly clean, we immediately attempted to substitute plain protection, using paraffin dressing or boric ointment. This substitution or "switching time" for the treatment proved to us to be a very important one. At one stage paraffin applied over the surface, dressing reapplied in some cases every twenty-four hours, in others forty-eight hours, depending on discharge, seemed to be just the proper procedure and produced remarkable results. (Fig. 14, entire back a delicate film of new skin.) Whereas in other cases this same procedure after continued application seemed to be of no value, and substituting a thin film of boric ointment on a fairly solid backed dressing, such as linen or lint, produced the same spreading new skin, over remarkable areas.

In a few cases all of these combined methods failed. It was found that continuous paraffin or ointment protection gave tremendous amounts of discharge with heaping up of granulation tissue and no healing. In these cases cauterization with silver nitrate followed by boric ointment on lint, smoothed down firmly across the area, aided in spreading over the delicate edge of epithelium. We consider the bridge-like action of a gentle but firmly applied piece of ointment protected lint to have an absolute effect in aiding these delicate epithelial cells in their effort to spread over the area, and consider its use directly responsible, together with the paraffin protection method, for our enormous areas of skin re-epithelization and the non-necessity for application of skin grafts.

SUMMARY AND CONCLUSIONS

Our experience demonstrated to us the value of the following: The need for the quick institution of immediate general supportive measures in patients suffering from extensive burns. The value of fluids in large quantities by mouth and bowel, even before the so-called toxæmia or acidosis symptoms commence to appear. Later, during the absorption period, from large infected areas, the addition of the continuous use of small doses of morphine sulphate seemed to us to be of distinct advantage. It certainly serves to keep the patient quiet and thereby reserves his energy for later use. Too much stress cannot be laid on the value

of these general measures, used as a prophylactic procedure, immediately following injury, before the advent of those well-known toxic symptoms, which are sure to follow in one extensively burned. We deem them far more important than any value obtained by laying too much stress upon the burned area during this initial period. It was again proved to us: That patients extensively burned quickly go into a severe shock the first twelve hours. That reaction from this period may be followed by an equally fatal period on about the fourth or fifth day. That recovery from this secondary period is later followed about fourth or fifth week by a period in which the element of exhaustion is a very important consideration.

Our local procedures demonstrated the following: Initial antiseptic cleansing. Alcohol, boric acid solution, salt solution, Dakin's, Wright's solutions all proving equally efficacious. Gentle dressing manipulation during this period with traumatism reduced to a minimum. As soon as possible the application of a simple protectorant, paraffin, ointment, gutta percha or rubber strips.

Our local measures again proved to us: That no one procedure, wet or dry dressing, wax, ointment, or that no one solution proves equally valuable for all cases. That the individual question of how the particular area reacts to the solution used is an important one. That there is a distinct difference between the mild stimulation and healing effect of bland protectants such as wax, liquid petrolatum and vaseline. That the so-called "switching time" in the application of these various dressings is a distinctly important one. That some patients cannot tolerate open-air exposure. That the absolute non-interference and non-removal of semi-adherent tags of skin is usually the best procedure.

MYXOMA

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"THE myxomata are tumors composed, in the main, of a tissue resembling none found normal in the adult organism, namely, a tissue composed of well-formed isolated cells of a somewhat stellate or polyhedral appearance, giving off delicate processes, the individual cells being separated one from the other by a matrix containing varying amounts of mucin, which takes on a differential stain with thionin. In this matrix there run large but thin-walled vessels. Some leucocytes are also present. We say formed in the main of such tissue, for it is very rarely that we come across what may be termed pure myxoma; in general, areas of the tumor show more condensed fibrous tissue, or cartilaginous masses, or frequently lobules or collection of fat cells, while in other cases portions are of sarcomatous type and show close collections of spindle cells. Thus, many pathologists doubt whether we ought to regard the myxoma as a separate form of tumor, and urge that we should speak rather of myxomatous modification or degeneration of some one or other form of connective-tissue neoplasm—of lipoma, chondroma, or fibroma myxomatodes, rather than of myxolipoma, etc. As such the majority of so-called myxomas must be regarded. But Ribbert has described small pure myxomatous tumors of the endocardium. Further, cases have been recorded as congenital myxoma, the tumors being recognized at the time of birth."¹

Adami,² in writing of congenital myxomas, cites a case reported by Borst of a colossal growth upon the mesentery of a child nine months old. This exhibited extensive lymphangiectasis, to which he ascribes the soft nature of the growth; there were correspondingly dilated blood-vessels. He ascribes the tumor to a persistence and continued growth of the embryonal mucoid tissue of the mesentery.

Bland Sutton³ says, "It would be convenient and perfectly justifiable to deprive myxomata of even the rank of species among tumors." He exemplifies by citing myxomas springing from lumbar fascia and recurring after removal; in one case there were several recurrences extending over a period of ten years, with no evidence of dissemination.

Mallory⁴ defines myxoma as a "tumor of mesenchymal origin of which the cells tend to produce mucin in addition to fibroglia, collagen, and elastic fibrils." He further states it is "a comparatively rare tumor and therefore clinically of minor importance. It is questionable whether it deserves recognition as an entity."

"A true primary myxoma which has its origin from embryonal mucous tissue is rare. Fully developed mucous tissue exists in the embryo only in the umbilical cord. The chief source may be found in

the early undifferentiated connective tissue of the embryo which has a mucous quality. Such mucous tissue is widely distributed, especially in subcutaneous areas. That many primary myxomas arise from islands of such embryonal tissue.

"Secondary myxomas may develop by degeneration of mesoblastic tumors, such as occurs in fibroma, lipoma, and chondroma.

"That these phenomena may be explained by assuming their origin from islands of mucous tissue which are partly differentiated. Pure myxomas never tend to differentiate into fibroma or lipoma or chondroma.⁵"

MacCallum⁶ writes: "Ribbert makes a point of declaring that in those frequent cases in which a complex or teratomatous tumor presents patches of muroid tissue here and there, the myxomatous part is not to be regarded as a secondary degeneration of some other part of the tumor. In other words, he maintains the independence of the myxoma as a distinct tumor which may be combined with cartilage or with bone, etc., to form a myxochondroma or myxoosteoma."

Dennis⁷ considers a pure myxoma of rare occurrence; and that irritation leading to a chronic inflammation seems to act as an exciting cause in many cases, examples of which are seen in polypoid growths of the nose and ear in patients in whom a chronic catarrh or otitis has existed for a long time.

Multiple tumors of a myxomatous nature in skin and organs of animals and fowls have been produced by experimental inoculation of a filterable virus.⁸

Composed, as they are, of a type of tissue from which fat tissue is developed in the embryo, the relations of myxomata to fat tissue are very intimate. They are most frequently developed in, and probably directly from, fat tissue. They are also found in the subcutaneous, submucous, and subserous tissue, in the marrow and periosteum; in the brain and cord; in the sheaths and intrafascicular tissue of peripheral nerves; in intermuscular septa; and in the interstitial tissue of glands, such as the mamma and parotid.⁹

Robertson¹⁰ in an analysis of 51 cases of lipoma myxomatodes found that 43 per cent. developed in the muscles of lower extremities, 33 per cent. in the retroperitoneal region, one reached a weight of 65 pounds and 33 per cent. were malignant.

McMahon and Carman¹¹ claim the röntgen shadows of fibromyxoma of lung are significant. The "increased density is large, massive, homogeneous, and well circumscribed. An entire lobe is usually involved, most commonly the upper."

Ester¹² reports a case of fibromyxoma of small intestine. The tumor was hemispherical in shape, 4 cm. in diameter. Microscopically the tumor was a myxofibroma, which in its superficial part approached the histologic type of pure myxoma; the basal part showed the structure of diffuse fibromyxoma.

In the testis, spermatic cord, and possibly in the kidney myxomas are probably of teratoid origin, and in some other regions, as parotid, breast, they represent mixed tumors.¹³

Adami¹⁴ considers myxomas of kidney rare. Most of tumors described he regards as connective tissue growths that have undergone secondary mucinous degeneration. Bezold and Hallen, however, have each reported a case of true myxoma.

Dabney¹⁵ reports two cases of true myxoma of the rhinopharynx.

Brenner collected 33 cases of cardiac myxomas; 20 of the left auricle; 10 on the heart valves; 2 right ventricle; 1 on the apex.

Ewing¹⁶ believes the tumors develop from superfluous embryonal tissue in the region of foramen ovale.

Curtiss expressed the view that they are not true myxomas; that the nodular outgrowths of the endocardium are due to infection, and mechanical influences stimulate their growth.

Cotton¹⁷ reports a case of myxoma involving the whole shaft of femur from neck to condyles.

Bloodgood¹⁸ reports 5 collected cases of pure myxoma without cysts affecting the medullary cavity of the phalanx.

He further states: "Pure myxomas are rare bone tumors. I have observed one exhibiting itself as an exostosis of the shaft of the humerus; I have seen it combined with cartilage as a multiple lesion arising from the rib, and as a periosteal growth from the os calcis."

He further comments on the above cases: "Myxomatous tissue is not unlike osteitis fibrosa. It seems remarkable that the majority of marrow tumors of the phalanges are myxomatous: of the metatarsal or metacarpal, cysts in osteitis fibrosa; and of the lower end of the ulna and radius, giant-cell tumors."¹⁹

In Virchow's "myxoma chorii" there is not only hypertrophy of villi but cystic metamorphosis. This infiltration of the enlarged chorionic villi, with abundant gelatinous fluid, simulates Wharton's jelly. Virchow further recognized a diffuse myxoma of the chorion developing from an increase in the embryonic connective tissue that normally is present between chorion and amnion.²⁰

Other structures of the body are susceptible to pure myxoma. Many case reports affecting the nervous system, brain, ulnar nerve, and many of the optic nerve. Winogradow reports a case of myxoma of the thymus gland; Ewing of the placenta and a cystic myxoma of the umbilical cord and navel measuring 10 cm. in diameter. Virchow reports myxoma of labium which recurred and eventually produced many myxomatous metastases. Ewing aptly says "the interpretation of any one of these tumors should be influenced by our knowledge of the entire group."

In reporting the following case, attention is directed to these salient features: the tumor represents a true myxoma; its unusual location; the

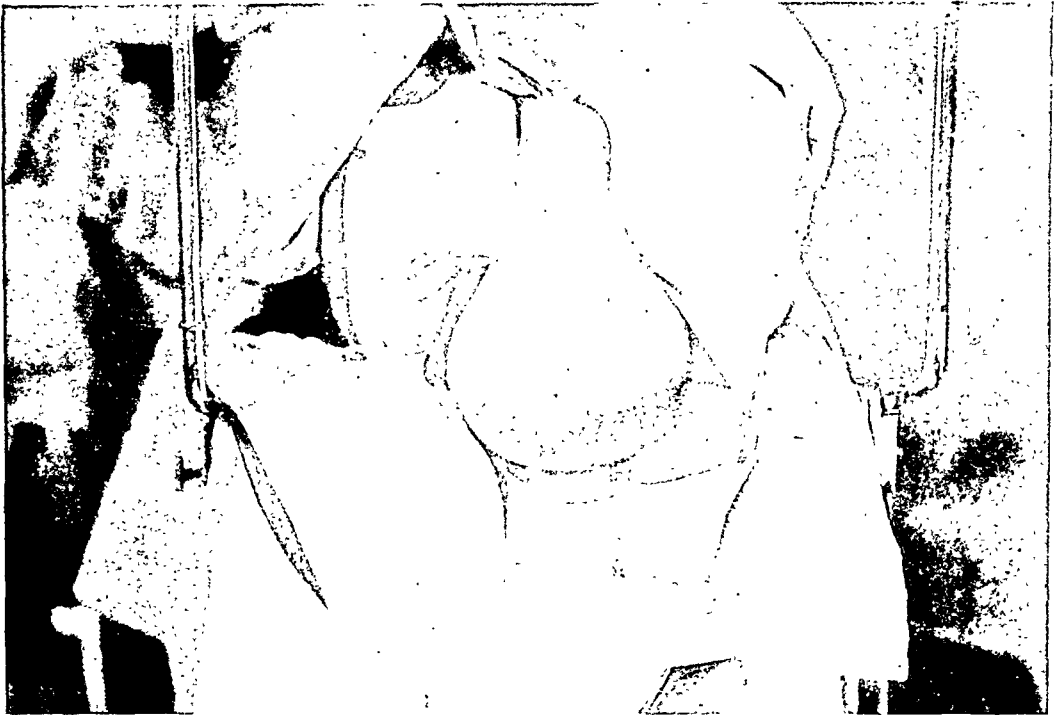


FIG. 1.—Pure myxoma of labium majus. Weight, 7 pounds, diameter, 8 inches. Note attachment to pubic area by broad pedicle.

disparity in size with usual pure myxoma; the slow growth with the absence of pain; and the reflex disturbances it produced in the causation of frontal headaches and indigestion. Agreeing with the later writers of pathology I am convinced that pure myxoma should be classified as an entity.

Miss W., American, aged fifty, weight 135 pounds, single, nervous temperament, both family and personal history negative; has suffered from frontal headaches and indigestion for past year.

Five years ago noticed a small tumor on right labia, upper third. This has steadily increased in size to present extent (Fig. 1). Never has caused any pain and is insensitive to manipulation or pressure.

Excision of tumor March 28, 1918. The tumor encroached upon the pubic bone and infiltrated the surrounding soft tissues.

Her convalescence was interrupted on the eighth day by a secondary hemorrhage. Some suppuration ensued. The wound healed and she was discharged three weeks later with some inflammatory thickening of labia.

Examination (three months later).—Parts normal, weight 156 pounds, headaches ceased. Letter received from her April 29, 1919. States: No headaches since operation, no recurrence, weight 177 pounds.

Pathological Report (Dr. Hindman).—Tumor, weight seven pounds, diameters eight inches. Entire tumor, on incision, reveals the characteristic soft gelatinous mass of pure myxoma. Different microscopical sections show a typical primary myxoma with some included glandular structure and a slight round-cell infiltration at periphery.

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FIBROMA OF THE INTERNAL OBLIQUE AND TRANSVERSALIS MUSCLES *

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A WOMAN, twenty-eight years of age, was admitted to Bellevue Hospital, January 13, 1919. She had a pendulous growth, about 11 by 8 cm., growing apparently from the crest of the iliac bone. The growth started about three years ago, as a small tumor of the size of a walnut. It has steadily increased in size up to the present. There was no pain except that when the weather changed the patient felt a sticking pain which did not radiate.

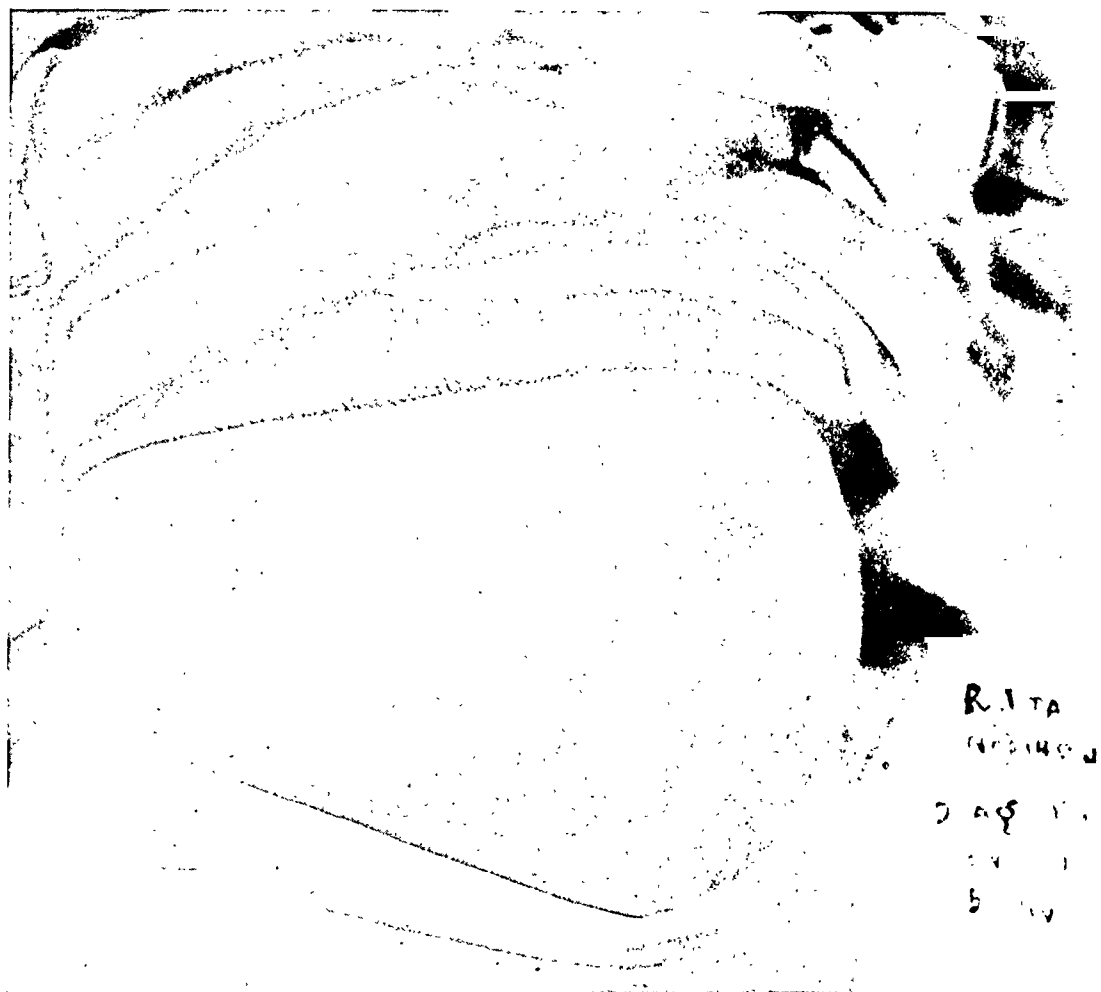
On the right side just above the anterior superior spine of the ilium was a tumor, 11 cm. by 8 cm. extending about 2.5 cm. to the right of the ilium. The skin was movable over the tumor. The tumor was slightly movable on underlying tissues.

Operation.—An incision was made 8 cm. in length in the direction of the fibres of the external oblique muscle from above across to the rim of the external inguinal ring. The tumor was found growing in the fibres of the internal oblique and transversalis muscles. The external oblique was not adherent to it. The tumor was excised, removing with it some of the muscle and some of the sheath of the rectus. The character of the tumor was hard and apparently of a fibrous nature, probably a fibromyoma of the internal oblique and transversalis. The peritoneum was of necessity opened in two places. The uterus and appendix were examined and found to be normal, except that there was a small fibrous nodule near the cervix. After examination of the appendix and uterus, the peritoneum was closed with chromic gut sutures. The edge of the rectus was pulled over and sutured to the origin of the internal oblique and transversalis, thus closing over the large defect made by the removal of the tumor. The external oblique was then closed in the ordinary manner of the McBurney incision, using interrupted chromic gut sutures and overlapping the edges. The skin was closed by interrupted sutures.

On section the tumor appeared hard and was pale yellowish pink and had the appearance of a fibroma. It was 11 cm. long and 9 cm. wide by 7 cm. in thickness. There was no pedicle to it. In removing it several large vessels had to be ligated.

Examination (by Dr. John McWhorter, Pathologist).—Macroscopical examination: The section consisted of a circumscribed, apparently encapsulated mass, 12 x 6 x 10 cm. The outer surface had a somewhat nodular appearance, was of a greenish color and appeared to be covered by a thin membrane. On section the tumor was dense, the cut surface was of a whitish color, and was

* Presented before the N. Y. Surgical Society, March 12, 1919.



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FIG. 1.

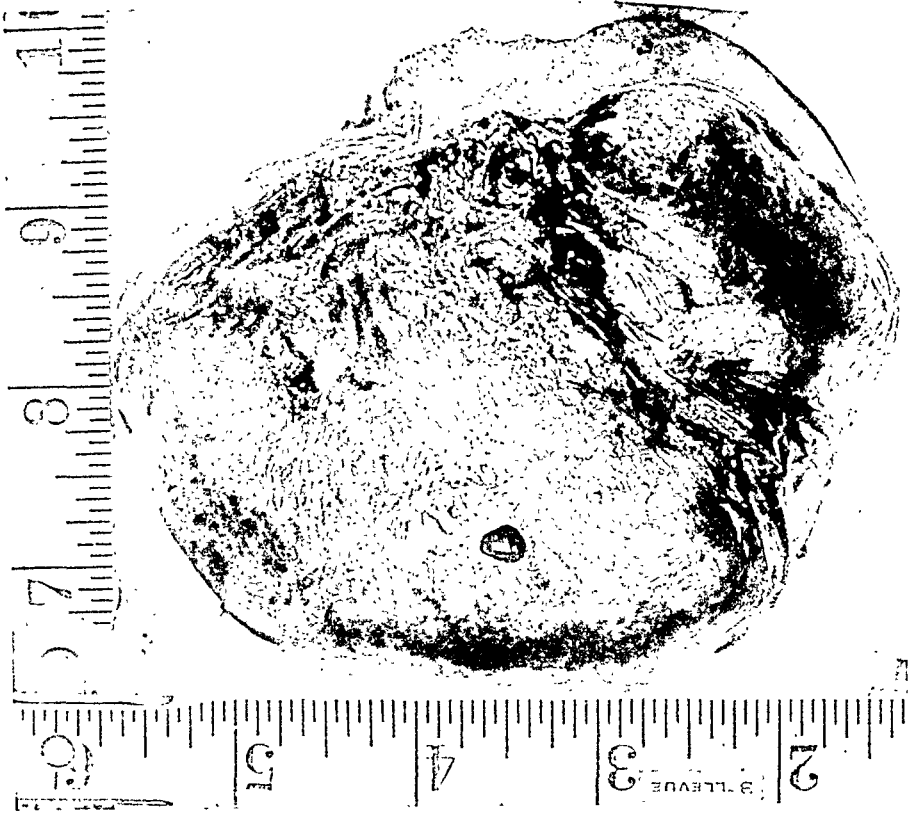


FIG. 2.



FIG. 3.

made up of a series of nodules which were regular in shape and separated one from the other. Microscopical examination: The section showed a mass of connective tissue which was surrounded by a capsule. The connective tissue consisted of a dense mass of interwoven fibers, which extended throughout the whole specimen. In a number of very small areas the connective tissue had a somewhat cellular appearance. The tumor as a whole was moderately vascular. Diagnosis: Fibroma.

In the third volume of the "Précis de Pathologie Chirurgicale," to which Duval, Lecène, Gosset and Lenormant have contributed, there is an excellent discussion on fibromata of the abdominal wall. They report that these have been described by Huguier and well studied by Guyon in 1876-1877, and Labbé and Remy in 1888.

The authors go on to say they are encountered almost exclusively in women during the period of sexual activity. Out of 100 cases observed only 4 were in men. Senn, in his work on the Pathology and Surgical Treatment of Tumors, in speaking of fibromata of the abdominal wall, says of 42 cases collected by Guerrien there were 39 women and 3 men. Of 70 cases of tumor of the abdominal wall collected by Sängér, 60 were fibromata. The efforts of childbirth, aided by strains of the aponeuroses appear to play a rôle in the production of these tumors, according to the majority of writers.

The fibromata observed are almost always single. Their place of most frequent development is the region of the rectus muscle and the inguinal region. (One other case I have observed was in the right inguinal region rather high up.)

The fibroma is always under the superficial aponeurosis. It is often fused with the aponeurosis and with the peritoneum. This last fact was also noted by the elder Senn, who reported four such tumors (Senn, Pathology and Surgical Treatment of Tumors, 1895).

"The majority of writers have insisted that they were encapsulated, a fact which permitted peeling them out. Lecène and Delamare have recently published facts which contradict this classic opinion, and conclude from their observations that the fibromata of the abdominal wall are not always in the whole extent of their circumference enucleable: There always exists a more or less extended surface where the tumor fuses itself with the muscle and aponeurosis, and even infiltrates them by taking the place of muscular elements." (In this case presented this evening this had taken place. The tumor appeared to have the muscular fibre running right into it.)

"Never have they been able to confirm either anatomically or by operation the existence of a vascular pedicle attaching the tumor to the iliac bone or to the ribs. Secondary adhesions to the bone have perhaps been observed" (Guyon).

"Histologically the fibromata of the abdominal wall are pure fibromata, slightly vascular, of which on the surface of the tumor one has been able to encounter enormous veins."

Exceptionally cellular elements have been demonstrated, making one think of fibrosarcoma in part of the tumor. "The fibroma infiltrates itself in the muscles and destroys them, in the meanwhile substituting itself progressively in place of the striated muscle fibres, which explains the possibility of a recurrence at the site of an incomplete extirpation" (Lecène and Delamare).

According to Senn: "Great confusion has existed in regard to the proper classification of these tumors. Some authors are inclined to regard them as a variety of fascial sarcoma. . . . They seldom recur after thorough extirpation and their histological structure bears a closer resemblance to fibroma and keloid than to sarcoma. To distinguish them from ordinary fibroma it is well to retain the name *desmoid*, a term applied by Müller to benign connective-tissue tumors."

Pathogenesis.—Huguier and Nélaton maintain the osteoperiosteal origin of the tumor. But it is demonstrated that the pedicle of the osseous insertion does not exist. (In my case there was no periosteal connection.)

“Labbé and Remy after Guyon have thought that there occurred exuberant fibrous cicatrices following muscular tears produced by the efforts of childbirth.”

As opposed to the theory that they develop in the round ligament it may be said that they do not always occur in this region.

“The prognosis is fairly good for it so happens that the benign tumor does not recur if its extirpation has been quite complete.”

(The removal should be by resection keeping well outside of the tumor mass. This leaves a large defect in the abdominal wall to be repaired by layers after the manner of a ventral hernia.)

UMBILICAL TERATOMA

A REPORT OF A CASE CONTAINING PANCREAS AND INTESTINE

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THE following case seems to be sufficiently unique to justify its being recorded:

The patient was a male child, aged two years and four months, who was admitted to the St. Louis Children's Hospital March 26, 1919, for treatment of an ulceration and persistent watery discharge from the umbilicus. The child had always been well except for an attack of diarrhoea in September, 1918, which cleared up promptly after regulation of diet. When the patient was approximately one year old, the mother first noticed an ulceration about the umbilicus associated with a constant discharge of a thin colorless fluid. The ulceration had never healed and the discharge had been continuous.

Examination revealed a healthy child with no abnormalities except those referable to the umbilicus. The umbilicus was replaced by an ulcer approximately 1 x 2 cm. The outline of the ulcer was that of a triangle with the base superior and the apex toward the symphysis pubis. The superior margin of the ulcer was overhanging. The lateral margins were sloping. The edge of the epithelium was serrated but always abrupt. There was no visible growth of epithelium over the base of the ulcer. The base of the ulcer was a brownish-red color, and bled after slight injury. Under the overhanging superior margin of the ulcer was a small sinus into which a probe could be passed for a distance of 3 cm. There was a constant discharge of a thin watery fluid from the sinus. The freely secreted fluid was colorless and odorless, but gauze dressings which had been in contact with the wound for twenty-four hours were stained a dark brown color and had an odor distinctly like intestinal contents. The amount of fluid discharged was not measured; it was only enough to keep a small gauze dressing moist. No chemical examination of the fluid was made.

At operation, an elliptical incision, with the larger diameter transverse, was made about the ulcerating area on the abdominal wall. The incision was carried through the subcutaneous tissue and the anterior sheaths of the recti muscles were opened by transverse incisions. The muscles were retracted laterally and the peritoneum was opened. On the peritoneal surface of the umbilical region there was a spherical tumor approximately 2 cm. in diameter. There was no visible connection of this tumor with any other structure. Owing to the fact that the operation was done in the presence of a chronic ulceration no extensive exploration of the

abdomen to determine the presence or absence of a Meckel's diverticulum could be carried out. The tumor, sinus, and ulcer were excised in one piece. The wound was closed in the manner of closure of an umbilical hernia, except that a small drain was placed in the subcutaneous tissue.

Following operation there was a mild wound infection which healed slowly and the patient was discharged well.

Examination of the specimen removed at operation showed the ulcerating surface as previously described (Fig. 1). On the peritoneal surface opposite the ulcer was a spherical tumor 2 cm. in diameter (Fig. 2). The peritoneal surface of the tumor resembled the peritoneal surface of a loop of intestine. A probe passed into the sinus in the ulcer entered the tumor. The tissue was hardened in formalin before cutting. On section the similarity of the tumor to tissue of the gastro-intestinal tract was clearly revealed. The relation of the different elements of the tumor is shown in the photograph of the section of the specimen (Fig. 3).

Microscopical examination showed the spherical tumor to be composed of tissues corresponding to those forming normal intestine. Peritoneum, muscle, nerve cells, submucosa, lymphoid nodules, and mucosa were all present in their usual relations. The mucosa corresponded in the character of cells and arrangement of the glands to the mucosa of the normal duodenum (Fig. 4). A few of the epithelial cells of the deeper glands took the eosin stain but in no instance were the staining properties of, and arrangement of, these cells such as to suggest the correspondence to gastric mucosa. There was evidence of chronic inflammatory disease particularly shown by a diffuse infiltration of the submucosa by eosinophilic polymorphonuclear leucocytes.

In the wall of the tumor adjacent to the peritoneum was a small island of normal pancreas. The gland was lobulated. The arrangement of the acini and ducts was the same as that of the normal pancreas. The external opening of the main duct was not found. There were a large number of typically normal islands of Langerhans in the pancreatic tissue (Fig. 5).

This case in which an isolated miniature intestinal apparatus was found at the umbilicus undoubtedly is an instance in which the omphalo-mesenteric duct failed to disappear entirely. Such cases are not exceedingly uncommon. The remnant of the omphalo-mesenteric duct, however, usually manifests itself as a Meckel's diverticulum or a sinus at the umbilicus lined with epithelium similar to that lining the intestine. In a few instances it has been found that the epithelium of a congenital umbilical sinus is similar to the gastric mucosa, and in at least two instances (Tillmans¹ and Denucé²), the fluid secreted has been found to be similar to gastric juice. Instances of accessory pancreatic tissue are also not rare. Opie³ found ten instances in eighteen hundred autopsies performed at the Johns Hopkins Hospital in which one or more accessory

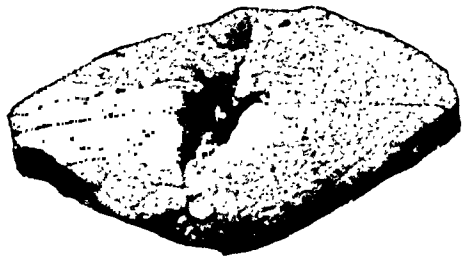


FIG. 1.—Photograph of the ventral surface of the tissue removed at operation, showing the ulcer which has replaced the umbilicus.



FIG. 2.—Photograph of the dorsal surface of the tissue removed at operation, showing the spherical tumor which projected into the peritoneal cavity. *Pt.*, cut edge of the peritoneum.

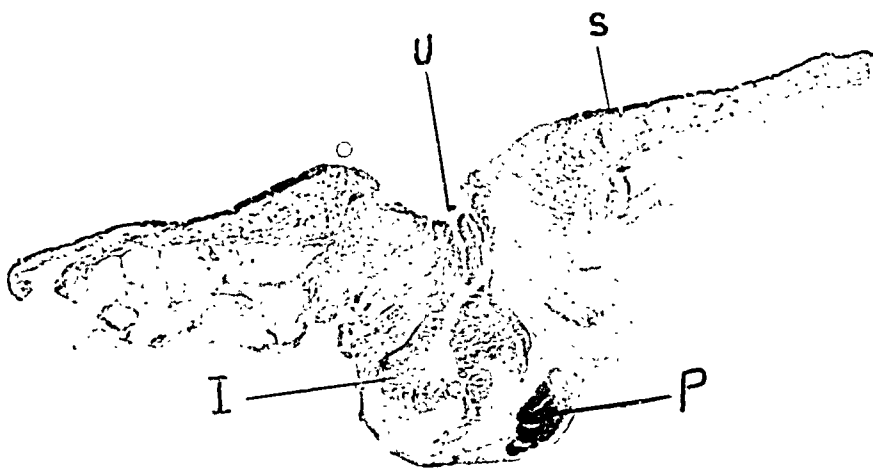


FIG. 3.—Transverse section through the ulcer, fistula, and tumor. U, ulcer. S, skin. I, intestine. P, pancreas.



FIG. 4.—Photomicrograph showing the character of the mucosa of the intestinal portion of the tumor.

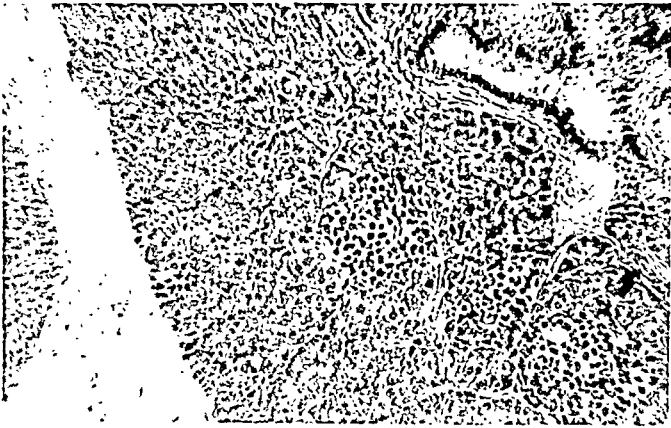


FIG. 5.—Photomicrograph of a portion of the pancreatic tissue, showing the gland acini, a duct, and islands of Langerhans.

pancreatic glands were present. Such isolated islands of pancreatic tissue are usually found in the wall of the gastro-intestinal tract in the region of the normally placed gland. Not uncommonly an aberrant pancreas is found in the tip of an intestinal diverticulum, and in at least four instances it has been believed that the diverticula containing the aberrant pancreatic tissue were true Meckel's diverticula. Zenker,⁴ Albrecht,⁵ Brünner,⁶ Dévé.⁷ Neumann⁸ expressed the view that an accessory pancreas could not occupy the summit of a diverticulum formed as a result of a persistent part of the omphalo-mesenteric duct because the pancreas did not begin to form until the omphalo-mesenteric duct had already been developed. He believed that a diverticulum having aberrant pancreas at the tip developed as a result of the traction of the aberrant gland on the intestinal wall. Nauwerk⁹ and Hansemann¹⁰ concur in this view. It would seem that the instance described in this paper would prove that aberrant pancreas does exist in a persistent portion of the omphalo-mesenteric duct.

Wright¹¹ has described a case in which aberrant pancreas was found in the region of the umbilicus. The patient in whom this congenital anomaly occurred was a female child of twelve years of age, who had had an umbilical fistula since birth. Two surgical operations had failed to close the fistula. It was finally successfully treated by a complete excision of the entire fistulous tract. At the operation the peritoneal cavity was opened and no connection of the fistula with intestine could be made out. Examination of the tissue removed at operation showed a small nodule of pancreatic tissue imbedded in fibrous tissue near the summit of the umbilical sinus. No tissue similar to intestinal mucosa was found. It is possible that Wright's case was originally identical with the one reported in this paper and that the intestinal mucosa was destroyed at the previous surgical operations.

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A CASE IN WHICH FOR OVER THIRTY-FIVE YEARS A WOMAN DEFECATED AND URINATED, AND FOR ELEVEN YEARS MENSTRUATED BY THE RECTUM

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A CASE in which for over thirty-five years a woman defecated and urinated, and for eleven years menstruated by the rectum is worthy of a final record as an evidence of the possibilities of surgery and especially of the conclusive evidence it affords that the rectum can be utilized as a common cloaca for the urine and the menstrual flow as well as for the fæces for an indefinite period.

The condition necessitating this novel use of the rectum was a case of extensive and incurable vesico-vaginal and recto-vaginal fistulæ caused by sloughing as a complication of typhoid fever. Ultimately I entirely closed the vaginal outlet.

I first reported the case publicly in my Toner lecture delivered at the Smithsonian Institution in Washington on February 17, 1876. It appeared in print in March, 1877.

In February, 1876, she had been entirely cured for seven weeks. When the lecture was printed she had remained cured for fifteen months. At her death, May 24, 1911, she had been cured for thirty-five years and five months.

In *Surgery, Gynæcology and Obstetrics* (1917, vol. xxv, p. 391) Reuben Peterson has assembled 38 other similar cases in addition to two of his own, making 41 in all.

When my Toner lecture was delivered, February 17, 1876, only one similar case, by I. Baker Brown, had ever been published (*Trans. Obstet. Soc.*, London, 1864, v, p. 25). Of this I was ignorant. So far as I then knew I was the pioneer. I first learned of Baker Brown's case in January, 1919, when I found it in Peterson's paper.

In 1851, Maisonneuve had performed this operation for the first time, but it was not published until 1889. Rose had operated on three cases in 1872, 1883, and 1886, but they were published, one case in 1878, and the other two in 1903.

In 1898, in my "Surgical Complications and Sequels of Typhoid Fever," p. 80, I republished the case bringing the history up to the end of 1897. The present record carries it down fourteen years longer and up to the time of her death.

It is the only one of the 41 cases caused by typhoid fever. In 33 cases in

* Read before the American Surgical Association in Atlantic City, June, 1919.

which the cause of the condition was stated, 25 resulted from childbirth, and 4 from operations for cancer.

A brief abstract of the case as published in my Toner lecture in 1876 and in my book on the surgery of typhoid fever in 1898 and my later notes is as follows:

Mrs. M. D., thirty-five years old, first came under my observation in St. Mary's Hospital, Philadelphia, in 1873. In 1872 she nursed her husband in a fatal attack of typhoid fever and then fell ill of the same disease. About the fourth week the labia minora sloughed away and both urine and fæces escaped through the vagina. In October, 1872, she entered the hospital under the care of my colleague Doctor Grove. He tried three times unsuccessfully to close the fistulæ by plastic operations. When I succeeded to his service I also made three equally unsuccessful attempts. In December, 1875, being convinced of the impossibility of success, I proposed to her a, to me, wholly novel operation, *viz.*, the absolute closure of the vagina, leaving the fistulæ wide open. This would compel the urine and the menstrual blood to be voided through the rectum. I explained the operation and its consequences to herself physically and as to marriage very frankly to her. She at once accepted my proposition.

The operation was a success except at the anterior end of the cicatrix, which held everywhere else but failed at the internal end of what was left of the urethra, the vesical end of which had sloughed away. Several minor but always unsuccessful operations were done here. Finally, on December 28, 1875, I excised this small remnant of the urethra. This was her twelfth operation and was entirely successful. She had urinated, menstruated and defecated with entire comfort for seven weeks when I delivered the Toner lecture and described her case in full, February 17, 1876.

She had been a nurse and for nearly four years had been unable to earn a living. She had been socially and professionally a pariah by reason of the disgusting atmosphere in which she lived and moved. This successful operation restored her to her social world and to her means of earning a living. She urinated once or twice at night and five or six times during the day. Menstruation ceased in 1887, over eleven years after the operation.

After the operation fistulæ in the cicatrix broke out in 1877, 1896, and 1904, *i.e.*, at intervals of 2, 19, and 8 years, respectively. Usually they caused only a little leakage and only when in the erect posture. Once the fistula healed spontaneously, once after a minor operation. The third occurred in 1904 as follows:

In 1904, another small fistula appeared. However, as she was so slightly inconvenienced and as the escaping urine caused no odor about her person she did not consult me for two years. In October, 1906, at my suggestion, she entered the Jefferson Hospital under the care of Dr. Francis T. Stewart and Dr. F. H. Maier. They laid open several small pockets containing urinary concretions. This entirely relieved her.

In December, 1888, thirteen years after the vaginal closure, she sought my help and stated that the escape of urine was intermittent. Digital examination by the rectum showed that the recto-vaginal fistula had so contracted that it would only admit the tip of the finger. It also showed that there was a calculus in the vagina which acted like a ball valve and explained the intermittent urinary flow. By inserting a curved hæmostatic forceps I easily crushed the calculus. This consisted of urinary salts deposited on a small mass of fæces.

At the date of her death on May 24, 1911, at the age of seventy-three, she had remained dry and well, with the exception noted, for thirty-five years and five months after the closure of the vaginal outlet. During all this long period she urinated only once or twice at night and five or six times during the day. She was wholly satisfied with the result of her persistent optimism.

No ascending renal, vesical or uterine infection occurred at any time, nor did mucous membrane of the rectum at any time resent the constant presence of the urine or the periodical presence of the menstrual blood.

VAGINAL HERNIA *

By HORATIO B. SWEETSER, M.D.
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JUDGING from the very few cases reported, vaginal hernia must be of extremely rare occurrence, and for this reason I wish to put on record, as of interest, the following case:

Miss E. B., aged twenty-one years, white, single, waitress, was admitted to the Minneapolis City Hospital September 27, 1915. Her only complaint was the presence of a swelling which protruded from the posterior wall of the vagina at the perineal junction when she stood or strained, but which almost disappeared when lying down and relaxed. It interfered with her working, and, although it was painful, she had suffered no severe sudden attacks of pain. It was first noticed one year before while she was still in bed convalescing from a severe attack of typhoid fever, and since that time it had gradually increased in size. Aside from this attack of typhoid fever the only other factor in her history which might have a bearing on the etiology of the lesion was that, two years ago she had had both Fallopian tubes and appendix removed, probably for pyosalpinx; unknown whether vaginal drainage was employed.

Menstruation began at ten years of age, was irregular but without pain, usually lasted four or five days, and the last period was two weeks before admission. She had never been pregnant.

There was nothing of significance in her family history.

Physical Examination.—She was a well-nourished and rather stout girl with well-developed muscles. The abdominal wall was firm and presented a linear suprapubic scar five inches long in the middle line which was firmly healed and showed no hernial protrusion. There was no tenderness nor rigidity and no evidence of tumor.

The vaginal orifice was very much relaxed, and, upon straining and especially when in the upright position, the posterior wall projected through it in the middle line to the size of a small orange, exactly simulating a large rectocele; the perineum, however, was intact (Fig. 1). The rectum itself was not examined until the time of operation. When she lay on her back and ceased straining, the swelling became small and almost disappeared. Examination of the pelvic cavity per vagina showed the uterus in normal position and not prolapsed, the cervix small and the os vaginal. There was no cystocele, and the adnexa were not palpable. There was no tumor to be felt in the pelvis.

Operation (October 2, 1915).—Under anæsthesia, examination of

* Read before Western Surgical Association, Chicago, December, 1918.

rectum revealed the fact that it was not prolapsed at all into the apparent rectocele, and took no part in the formation of the swelling.

A transverse incision was made at the muco-cutaneous junction of the perineum, and a vertical median one up the posterior wall of the vagina and the flaps dissected back. The tumor wall, which was later found to be peritoneum, was very thin and was easily separated from the anterior rectal wall. The dissection was carried up to the level of the recto-uterine pouch behind the cervix. The sac was then opened and a large amount of yellowish fluid drained off, estimated at about a pint. No bowel coils appeared. Not being able to make out what the conditions were which we were encountering, the lower field was abandoned at this point, and the abdomen opened above the pubes. The omentum was found firmly attached to the uterus and broad ligaments. The tubes were absent. The ovaries were small and full of small cysts. When the omentum was detached and the coils of bowel separated, and the uterus drawn forward, an opening was discovered in the centre of the Douglas pouch, about one inch in diameter, through which the finger could be passed into the cyst below. There was no cyst wall above. The opening was closed by sutures including the sacro-uterine ligaments. The abdomen was closed without drain. Returning to the vagina the sac was twisted into a cord, tied and cut off, and the levator muscles sutured over the stump. The redundant vaginal wall was excised and the edges sutured. Fig. 2 is a sagittal view, showing the hernial sac as it dissected the recto-vaginal wall and projected from the vulva. Fig. 3 is a view from above, showing opening from cul-de-sac into hernial sac; closed by sutures at operation.

The patient left the hospital three weeks later, with the parts firmly healed. I have tried to trace her in order to report her present condition, but have not succeeded.

In seeking for an explanation of the conditions found, *viz.*, a hernial sac containing fluid but no intestine or other viscera, my theory is that at the operation for removal of the tubes the fibrous floor of the cul-de-sac was injured, and that at the same time there had developed a pelvic peritonitis which formed adhesions between the coils of bowel and the omentum, creating an encysted collection of fluid at the bottom of the cul-de-sac, the pressure of which caused a pouching downward of the peritoneum. That a year later, when she suffered the severe attack of typhoid, the tissues relaxed and allowed a protrusion of the hernial sac, into which the bowel could not enter because of the adhesions which held them up. Possibly a better and more probable explanation is to assume that the supposed typhoid fever attack was not typhoid at all, but rather a severe pelvic peritonitis which caused the encysted fluid to increase in quantity and in pressure, and that in this way the hernia developed rapidly, and travelled along the recto-vaginal plane, appearing at the perineum.

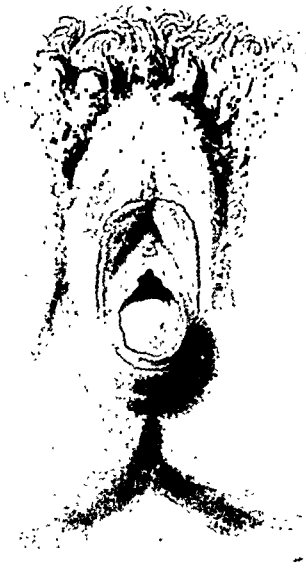


FIG. 1.

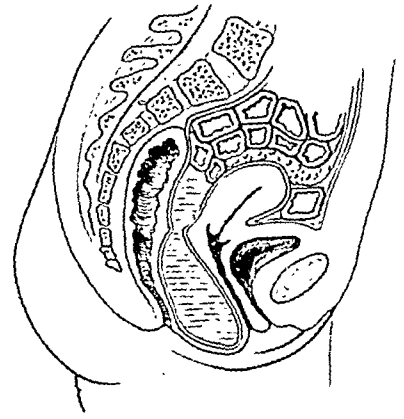


FIG. 2.

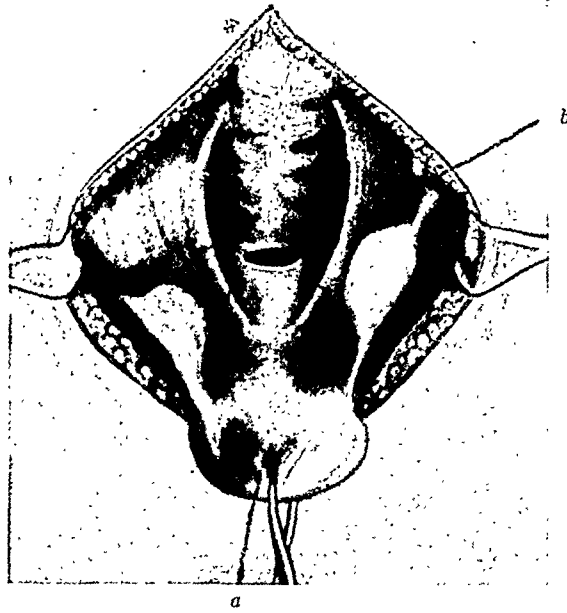


FIG. 3.—*a*, uterus drawn forward; *b*, hernial opening.

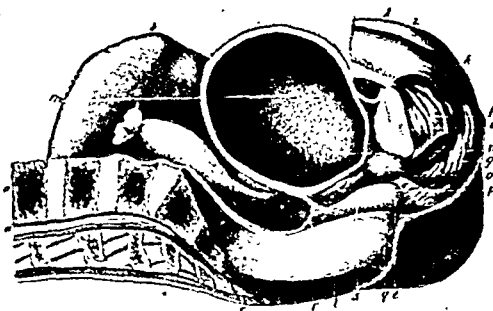


FIG. 4.—Astley Cooper's "hernia," 1804.

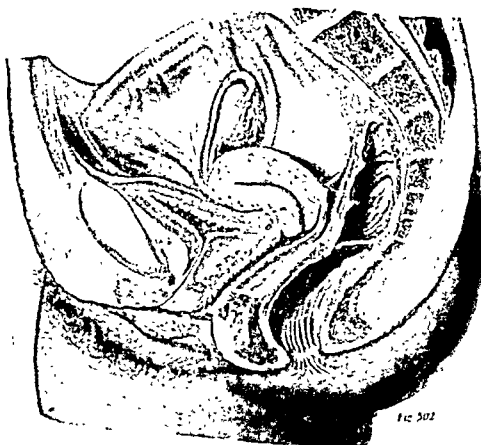


FIG. 5.—Sabotta's anatomy.

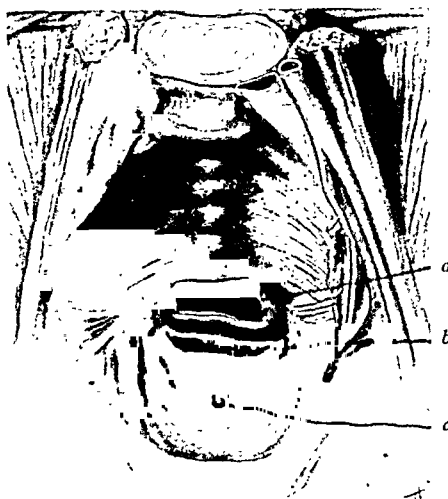


FIG. 6.—Dissection by Dr. L. A. Calkins. *a*, rectal opening; *b*, vaginal opening; *c*, urethral opening.

Very few cases of true vaginal hernia have been recorded, and fewer still have been operated on or come to dissection post-mortem. Barker states that no case was recorded in the first sixteen volumes of the "Transactions of the London Obstetrical Society." Most of the works on gynecology do not mention it at all; a few give it very scant notice, under the heading of pudendal and perineal hernia. Even works on hernia pass it by with very little comment. A search of the index of the Surgeon General's Office brings to light only a few articles, and these refer, more or less, to the same cases. It is difficult, therefore, to get a true idea of the pathology and pathogenesis, and of the proper course to pursue when dealing with them.

Sir Astley Cooper, in his classic work on hernia, published in 1804, reproduces a very clear and distinctive drawing which he made from a post-mortem specimen from a male subject. The course of the sac along the anterior rectal plane and its appearance in the perineum is so exactly similar to my case, making allowance for anatomical difference of sex, that I have taken the liberty of reproducing it. There is no history attached, the specimen having been found accidentally in the dissecting room. Fig. 4 was reproduced from Cooper's work on hernia (1804). Fig. 5 was reproduced from Sabotta, showing normal female sagittal section of pelvis.

Fordyce Barker, in an exhaustive article written in 1876, reported four cases, none fatal and none operated upon.

Gaillard Thomas, in 1885, in the course of an extensive paper, reports and illustrates a case of vaginal enterocele in which he opened the abdomen, caught the bottom of the sac with a long forceps, inverted and sewed it to the anterior abdominal wall and succeeded in curing his patient.

In recent years the only case I have been able to find is one reported by H. Hartman, in 1916, in a French journal (*Ann. de gynec. et d. obst.*), and abstracted in *Surgery, Gynecology and Obstetrics* of May, 1917. In his case the sac projected from the posterior wall of the vagina, but did not reach to the vulva. He operated entirely from below, excising the sac at the level of the uterine neck, and suturing the muscular floor below the stump. His patient had been operated on several times previously for supposed prolapse, always with return of the tumor, and he makes the statement that it is necessary, to prevent recurrence, that the sac must be excised and the vaginal wall reconstructed.

At first thought one would assume that the floor of the pelvis ought to be the favorite site for the occurrence of hernia, for the reasons that it lies at the bottom of the abdominal cavity where the intra-abdominal pressure is presumably greatest, is perforated by many small openings for the passage of blood-vessels and nerves and by the large openings for the urethra, vagina and rectum, and presents not infrequently defects in the muscular floor as pointed out by Ebner (25 in 60 cases examined). It

therefore appears quite remarkable that so few cases are on record. The explanation is two-fold, as pointed out by Sir Astley Cooper and C. Aston Key, many years ago: (1) The obliquity of the pelvic cavity is such that the intra-abdominal pressure is deflected from it and expended largely on the pubic bone and the anterior abdominal wall in the lower iliac regions, and (2) the pelvic floor is protected by the very strong pelvic and recto-vesical fasciæ, the fibres of which are intimately interwoven with the walls of the canals which pass through it. To illustrate this I wish to show a drawing from a beautiful recent dissection by Dr. L. A. Calkins of the Minnesota University Medical College. The peritoneum, together with the pelvic viscera, has been removed, in one piece, leaving the fascial and muscular layers through which project the terminations of the rectum, vagina and urethra. This forms a very strong floor covering in the pelvic outlet (Fig. 6).

Hernia appearing in the vagina may find an exit in front of or behind the broad ligament. Those in front descend between the ligament and the bladder and push forward the anterior wall of the vagina, usually to one or the other side. Those behind usually perforate some part of the levator-ani or coccygeus muscles or the interval between them and push the posterior wall of the vagina forward, and as a rule, laterally, and appear in the upper part of the vagina, or, if they come low, in the perineum on either side. Apparently very few go through the pouch in the centre, dissecting the recto-vaginal septum, pushing forward the posterior vaginal wall and appearing in the centre of the perineum, as in the case here presented.

As regards diagnosis, these herniæ have been mistaken for prolapse, for vaginal cyst and for abscess, and several have been operated on under such mistaken diagnosis, the gut being incised and even excised with fatal results. It is therefore well to bear in mind that such hernias do occasionally occur and have to be reckoned with.

As regards treatment it seems to me that operation is clearly indicated, both because of the danger of strangulation, and the interference with the delivery of a possible future child. The form that operation shall take will depend on the individual case. In some operation may be completed with perfect satisfaction from below, as was carried out by Hartman, but there is no question that cases will present in which it will be necessary to open the abdomen to get the best results, or where, as in my case, the exact pathology is uncertain.

WHY IS END-TO-END INTESTINAL ANASTOMOSIS UNSAFE ?

A CLINICAL AND EXPERIMENTAL STUDY OF TECHNIC, INDICATIONS AND CONTRAINDICATIONS FOR
END-TO-END ANASTOMOSIS OF THE SMALL INTESTINE AND THE COLON

By ANGELO L. SORESI, M.D.

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AT PRESENT SURGEON IN THE ITALIAN ARMY, OSPEDALE MILITARE PRINCIPALE, MILANO

THE dangers peculiar to resection and consequent anastomosis of any portion of the intestine are immediate and remote: immediately, that is, soon after the anastomosis has been performed, danger comes from the possibility of leakage into the abdominal cavity of intestinal contents or of purulent material, that might form and collect along the line of union; later the danger comes from the marked or complete stenosis at the point of anastomosis, which would interfere with or obstruct the free passage of the intestinal contents.

The end-to-end method of intestinal anastomosis is certainly the quickest and most physiological method of reuniting the divided gut, and would always be the method of choice but for the fact that it is not as safe as the side-to-side or oblique (author's) methods. It is not as safe as the other two methods, because after the two stumps of the gut have been united by the end-to-end method, the point of anastomosis might undergo a degree of constriction often dangerous, either immediately or after a certain time, and mostly because leakage occurs along the suture line with such frequency as to rightly give the surgeon the impression that the method is unsafe.

The mechanism of the production of stenosis along the line of suture is well understood as being caused by continuous retraction of the cicatricial tissue formed along the suture line as a ring, the circumference of which becomes smaller than the circumference of the gut; if this circumference becomes so small, as to be a serious obstacle to or to prevent the passage of the intestinal content, the stenosis becomes dangerous.

The mechanism by which leakage of intestinal contents occurs along the suture line is not so well understood and it is our purpose to bring forward certain facts and considerations that shall explain why it occurs and to suggest means to prevent it, as far as possible. We shall, however, immediately state that *technically speaking, it is impossible with any method and the most perfect technic imaginable, to perform an end-to-end intestinal anastomosis, either of the small intestine or of the colon, with the positive certainty that leakage will not take place.* The fault is not inherent to any method or to the lack of technical skill of the surgeon, but is inherent to the anatomical conditions in which the anastomosis is made.

CONSIDERATIONS ON THE ANATOMY OF THE INTESTINE

When the gut is anastomosed by the end-to-end method, when leakage occurs it is almost in every case at the so-called mesenteric angles. These mesenteric angles present a peculiar anatomical condition; the two leaves of the mesentery which surround the intestine leave between them a space irregularly triangular deprived of serosa. It is an axiom in surgery of the abdomen that union between the different parts of the gastro-intestinal tract takes place only when serous surfaces are approximated. Given the condition mentioned above, that the mesenteric angle is not lined with serosa, it was natural to think that this lack of serosa

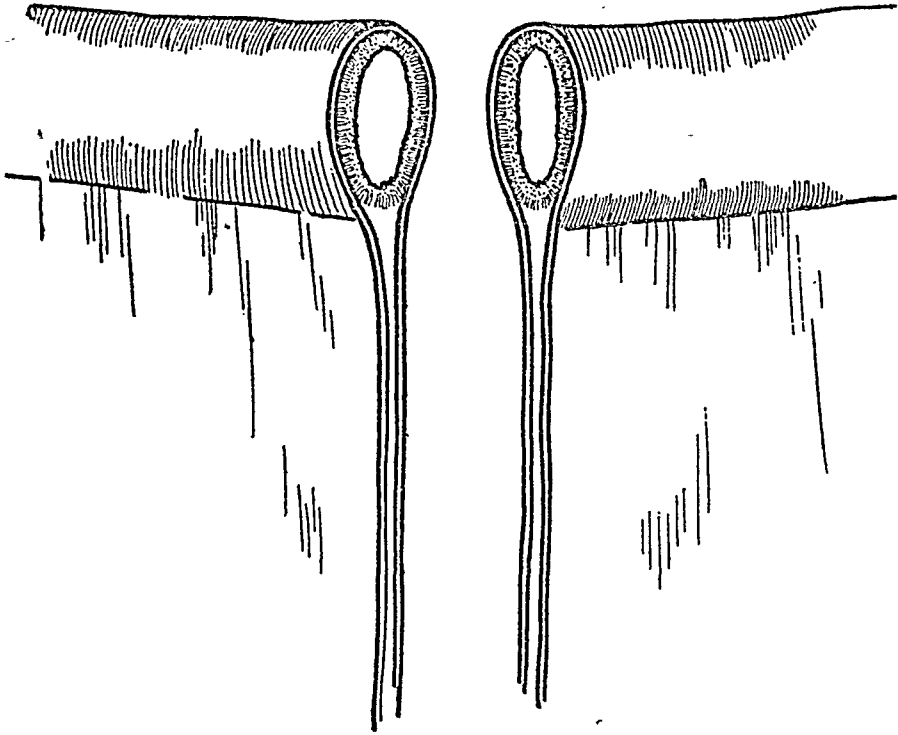


FIG. 1.—Schematic view of end-to-end intestinal anastomosis showing cut edges that have to be approximated and tissues interested.

was the immediate cause of leakage occurring after an end-to-end anastomosis of the intestine. This opinion is so rooted in the minds of surgeons that the triangular space has been called the dead dangerous mesenteric angle. If this view were really correct, it would be a very easy matter to make end-to-end anastomosis of the intestine perfectly safe; in fact, it would be sufficient to occlude entirely the triangular space, by approximating and inverting with a few stitches the two leaves of the mesentery. Instead of being such an easy matter, no method has been devised, and very likely none can be devised, which shall secure the mesenteric angles in such a manner as to make end-to-end anastomosis perfectly safe, as far as leakage from the mesenteric angles is concerned. This is due to the fact that leakage occurs at the mesenteric

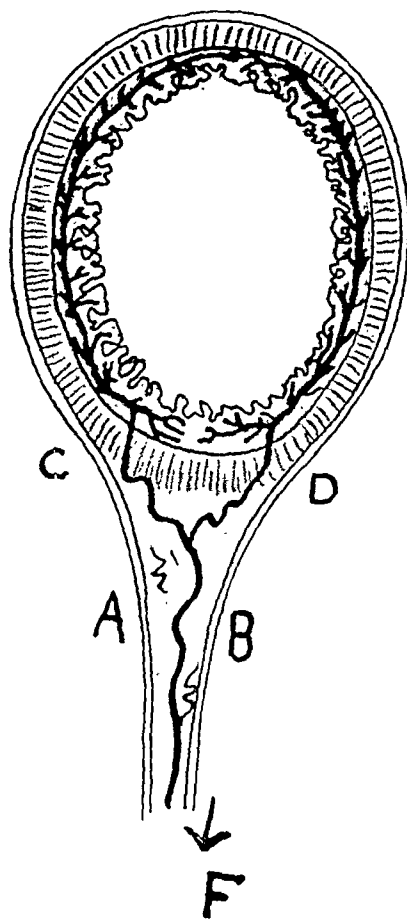


FIG. 2.—Section of intestine showing: A-B, the two leaves of the mesentery merging into the walls of the intestine at points C and D, forming a space that contains loose areolar tissue and the nervovascular system, having as borders: above, the portion of intestine found between points C and D, which is deprived of serosa, laterally, the two leaves of the mesentery A and B, below, the attachment of the mesentery to the posterior abdominal wall F (mesenteric space).

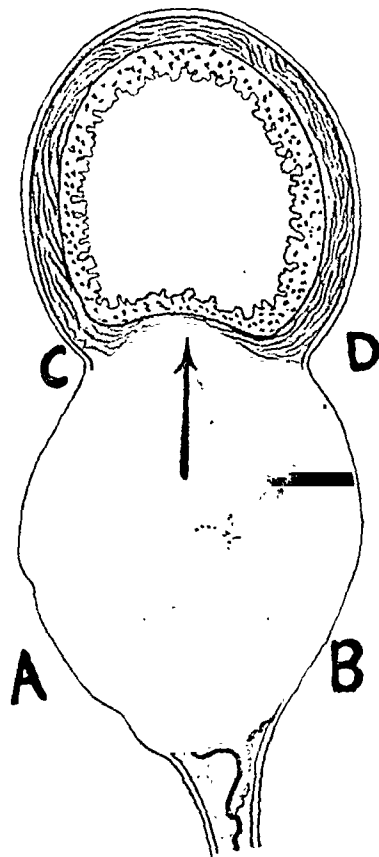


FIG. 5.

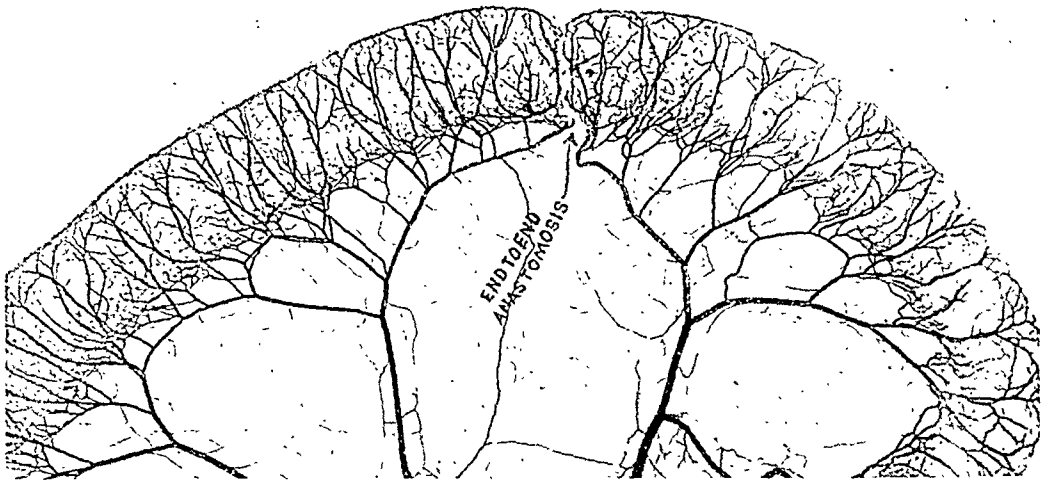


FIG. 3.—X-ray picture of intestine after an end-to-end anastomosis has been performed. This picture shows clearly the distribution of the blood-vessels in the intestine, their intimate and numerous anastomoses and how rich is the blood supply around the line of anastomosis except at the mesenteric spaces (mesenteric angles) where the blood supply is absolutely *nil*. This picture and Figs. 18 and 19 were obtained by injecting mercury into the large mesenteric vessels after the intestinal anastomosis had been performed.

angles, *not only because of the mere fact that there is a lack of serosa, but for other causes also*, and in order to understand and appreciate these causes, let us briefly examine the status and condition of the two stumps of the intestine as they are when ready to be anastomosed by the end-to-end method.

We have before us two segments of the gut as represented in Fig. 1 which have to be united by surfaces corresponding to their cut edges.

If we examine the cut edges we shall observe (Fig. 2) the following important features:

From below upward the mesentery represented by its two leaves A and B, which are separated from each other; at points C and D the two leaves of the mesentery merge into the intestinal wall forming its outer coat: so that the outer coat of the intestine is the result of the coalescence of the two leaves of the mesentery, and the intestine is surrounded by the two layers of the mesentery, which form its serous coat, except at the space comprised below and between points C and D. The space left between the two leaves of the mesentery is an indispensable and very ingenious arrangement of nature for the passage and protection of the whole nervo-vascular-lymphatic system of the intestine; that is, the mesenteric arteries and the mesenteric veins, the lymphatics and their ganglia, and the nervous plexuses. All these structures are surrounded by loose areolar tissue which contains in its meshes a quantity of fat more or less abundant according to the fatness of the subject. Let us call the attention to the fact that the two leaves of the mesentery do not form in reality a triangular space with the part of the gut that is not surrounded by serosa C-D, because this space is not closed at the bottom (Fig. 2); on the contrary, this space is nothing but a broader space than the space which exists between the two leaves of the mesentery A-B all the way from the root of the mesentery up to its insertion on the intestine, and it is only wider in very thin-subjects. In fat subjects a quantity of fat accumulates between the two leaves of the mesentery, increasing the space between them, so that the so-called triangular space is not a triangular space, but only an irregularly shaped space the form of which depends on the amount of fat deposited between the two leaves of the mesentery. So that we can truly state that, below points C and D, there is a space formed by the two leaves of the mesentery; this space has as borders on top the part of the gut comprised between points C and D, laterally the two leaves of the mesentery A and B, below the attachment of the mesentery on the posterior wall of the abdominal cavity. This space contains the blood-vessels, the nerves and the lymphatics of the intestine; is of irregular shape and filled with loose areolar tissue containing fat, and could more correctly be called upper mesenteric space, as we shall do in this paper.

Anastomosis.—Let us see now what the surgeon does in performing an end-to-end anastomosis.

He has to resect the gut; make a good hemostasis; reestablish the continuity of the intestinal canal by anastomosing the two stumps of the gut. Let us study thoroughly each of these steps. We beg to be pardoned if we insist on details that appear to be unimportant, but which, on the contrary, must be well understood and fully appreciated, if the whole mechanism of end-to-end anastomosis is to be made clear and plain.

Division of the Gut.—The intestine and the mesentery are divided either with scissors, knife, thermocautery; with any of the means employed, the cavity of the gut is laid open and the margins of the wound *will positively be contaminated more or less with the intestinal contents*. We wish to state that no matter how the severing of the intestine is done, how careful is the surgeon, what method is employed, the cut edges of the intestine will always be more or less infected; *an absolute or a complete asepsis or sterilization of the cut edges cannot be obtained*.

Hæmostasis.—After resection of the gut and of the mesentery hemorrhage would occur if the blood-vessels supplying the blood to the portion of the gut which is resected were not tied; so the surgeon must secure a good hæmostasis before performing the anastomosis. There are different manners by which hæmostasis can be secured. Whichever method is used the result is exactly the same, that is, it prevents hemorrhage from the cut edges of the blood-vessel passing through the severed mesentery. We have seen that the blood-vessels carrying blood to the intestine pass through the space left between the two leaves of the mesentery; these blood-vessels subdivide themselves as shown in Figs. 2 and 3 at the so-called mesenteric angle and surround the whole gut by an intimate and very intricate anastomosis of all the numerous smaller vessels in which the larger vessels coming from the division of the main ones at the mesenteric angle are subdivided in the submucosa. Hæmostasis, therefore, accomplishes exactly this; it prevents the flowing of blood to the cut edge of the divided vessels, which are located between the two leaves of the severed mesentery; therefore, it leaves the tissues in which these severed blood-vessels are located without any blood supply. As the blood-vessels are tied at a certain distance from the cut edges of the mesentery, it follows that the blood supply of the tissues found between the points where the blood-vessels are tied and at the very cut edges it is nil; they are bloodless.

Consequences of Hemostasis.—Let us see what are the consequences of this condition. Admitting that it is impossible, as we shall prove later, to avoid infection or to disinfect properly the cut edges of the divided gut, the loose areolar tissue filled with fat which is below and in immediate contact with the portion of the gut which is not surrounded by serosa (Fig 2, C-D) will positively be infected by being contaminated with the intestinal contents. The loose areolar tissue filled with fat is one of the least, if not the least, resistant tissue to infection and therefore would, even under the most favorable circumstances, always be a

dangerous tissue to have to deal with in performing an intestinal anastomosis. But the poor resistance of the loose areolar tissue and fat to infection is not the only element of danger; the greatest danger comes from the fact that its already little resistance to infection is still greatly decreased by these two factors. This tissue is traumatized either by forceps, thermocautery, ligatures, passing of needles and thread and by too often used and roughly applied sponging. Its blood supply has been absolutely and most completely cut off by tying the blood-vessels which were supplying blood. So that we have as a final condition the following: a tissue which has *per se* little resistance to infection; this resistance is still lessened by trauma and cutting off of blood supply. It would be hard to imagine a more favorable medium for the culture of microorganisms, than the space found between the two leaves of the mesentery: moisture, heat, closed space, and good nutrient medium supplied by the fat which is going to be dissolved; the little or much blood which is always left, even after the most careful hæmostasis, and by the foreign bodies left there, such as catgut; all this with the certainty that the microorganisms will not be disturbed, because the only elements which would be brought in by the blood and could disturb them are kept away by the good and secure hæmostasis made by the surgeon, that does not allow any blood to flow there. And as if one of these mesenteric spaces was not sufficient to hazard the safety of the anastomosis, the surgeon is compelled, in order to perform the end-to-end intestinal anastomosis, to put in the closest contact two of such spaces (Fig. 1), so that the infectious agents found in one will be helped in their work by their neighbors of the other stump. We see then that the danger from end-to-end intestinal anastomosis comes not from the mere fact that the intestine is deprived of serosa at the so-called mesenteric angle, but because the areolar tissue found there is always more or less infected and its already weak resistance to infection is still decreased, or better, rendered absolutely nil, by shutting off its immediate blood supply (Fig. 3). We see, therefore, that the dangers inherent to end-to-end intestinal anastomosis do not depend only on the method employed or on the skill of the surgeon, but depend on anatomical conditions which cannot be changed and that tend to make end-to-end intestinal anastomosis a method of uniting the gut which could be called a method scientifically incorrect.

Can Unfavorable Anatomical Conditions be Changed?—But let us suppose that between points C and D (Fig. 2) the intestine was surrounded by serosa or that we could seal the gut at the so-called mesenteric angles: what would happen? If the intestine was surrounded by serosa between points C and D we would have the following conditions when we make an end-to-end intestinal anastomosis: the loose areolar tissue containing fat found at the mesenteric angles would be surrounded, above by the serosa that we have supposed to exist between points C and D, laterally by the two leaves of the mesentery and below by the attach-

ment of the two leaves of the mesentery to the posterior abdominal wall; this areolar tissue, the blood supply of which has been shut off, is *positively infected, and cannot be sterilized*, is traumatized and contains the material used for the ligatures of its blood-vessels and perhaps some stagnant blood: adhesions would form between the serosas forming the two leaves of the mesenteries and the serosas we have supposed to exist between points C and D of both stumps of the intestine; therefore, we would have a cavity formed and closed up by the serosas of the two stumps of the intestine and the attachment of the mesentery to the posterior abdominal wall. What would happen in this closed and securely sealed cavity containing infected loose areolar tissue, fat, material used for the hæmostasis and perhaps some blood? There would be the formation of purulent material, which would keep increasing in quantity, because the loose areolar tissue which is found between the two leaves of the mesentery would be easy prey for the infecting micro-organisms: this purulent material could not be absorbed, because between the two leaves of the mesentery there are no tissues which could do so; therefore, either it would spread between the two leaves of the mesentery or break through somewhere, either into the abdominal cavity, or into the lumen of the intestine. The dangers of such a condition have only to be mentioned to make it clear that end-to-end anastomosis would be so dangerous as to be impracticable if the conditions of the intestine were as we have them supposed to be. The only remote hope for the patient's safety would be that the collection of pus would break into the lumen of the intestine before the pus had caused irremediable damage.

Infection of Mesenteric Angles.—Some readers might think that our statement that the mesenteric spaces (angles) will positively, absolutely, without any possible exception, be infected while severing the intestine and performing the anastomosis, and that they cannot be sterilized, does not correspond to a mathematical truth: the following experiments will prove our assertion to correspond to mathematical truth.

We assert most emphatically that purulent, highly infecting material always forms and collects at the mesenteric spaces (angles) when end-to-end intestinal anastomosis has been performed, because in many hundreds of end-to-end anastomoses performed on animals with every method known, using all possible precautions, severing the gut with the thermocautery, with the sharpest scissors and scalpels sterilized and then dipped in pure carbolic acid, so that the cut edge should be immediately sterilized by the action of the cautery or of the carbolic acid; by beginning the incision from the mesentery up to the mucosa, then cutting the mucosa with thermocautery or carbolized instruments; touching the mucosa with iodine, bichloride, 5 per cent. carbolic acid, formalin, ether, alcohol, and practically with any known other agent thought to have a strong or weak action against microorganisms, we have found *that the space called mesenteric space (angle) was always in every case highly infected from the*

very moment the anastomosis had been performed up to eight and, at times, many more days after, and that the use of any of the means mentioned was hampering the union of the resected gut; so that leakage occurred much more often when the thermocautery, carbolic acid or any supposed sterilizing agent was used, than when the gut was simply severed with knife or scissors and properly reunited, as shall be explained later.

We shall not relate in detail the experiments made, because we think that for the purpose of this paper it is sufficient to mention the results and how they were obtained. We have made hundreds of experiments in the following manner: After the anastomosis had been performed we reopened the abdomen, took up the part of the gut that had been anastomosed and separated with sterile instruments the mesentery close to and a little under its attachment to the intestine, so as to penetrate into the mesenteric space (angle) without, however, entering into the mucosa, collected on a platinum loop a little material, and in every case, up to the eighth day at least, after the anastomosis had been performed, we found that there were microorganisms present.

Why Does Leakage Not Occur in Every Case of End-to-End Intestinal Anastomosis?—That leakage does not occur in every case in which end-to-end intestinal anastomosis is performed, does not need any demonstration; we have to explain why it does not always occur. Let us look again at Fig. 2; we see that the two leaves of the mesentery blend so intimately with the intestine at points C and D as to form a whole with the intestine itself, so that it would not be possible to separate the serosa formed by the two leaves of the mesentery from the underlying tissue; the two leaves of the mesentery then continue separated from one another and attach themselves to the posterior abdominal wall. We have, therefore, a space which results formed by line C and D that is made up by that part of the intestine which is not surrounded by serosa, and the two leaves of the mesentery. This space is always infected and in performing the anastomosis is closed up and applied closely to the same space of the other segment of the gut. *In every case of end-to-end intestinal anastomosis there is the formation of a more or less abundant collection of purulent material at the so-called mesenteric angles; what happens to this purulent material?* If we examine again Figs. 2, 4, and 6 well we will easily understand why leakage does not occur in every case. We have a closed cavity, the walls of which are formed by the leaves of the mesentery of the two stumps of the gut, the top by the muscularis, submucosa and mucosa of the intestine which is comprised between points C and D, and the bottom by the fat found between the two leaves of the mesentery. That pus breaks through the points of least resistance is an axiom that needs only to be mentioned in order to explain why leakage does not occur in the abdominal cavity. The point of least resistance in an end-to-end anastomosis of the intestine is the union of the parts of the two segments of the intestine comprised between points C and D,

FIG. 7.

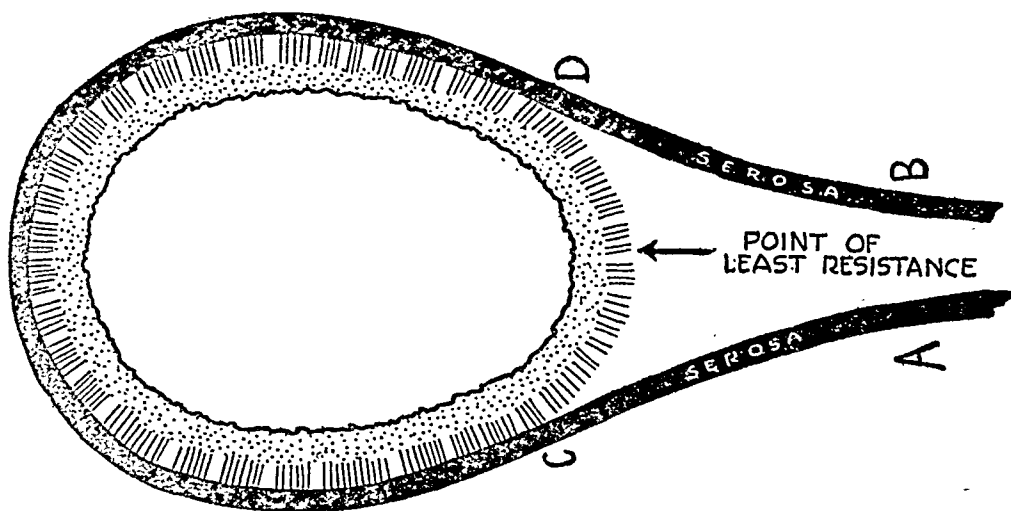


FIG. 6.

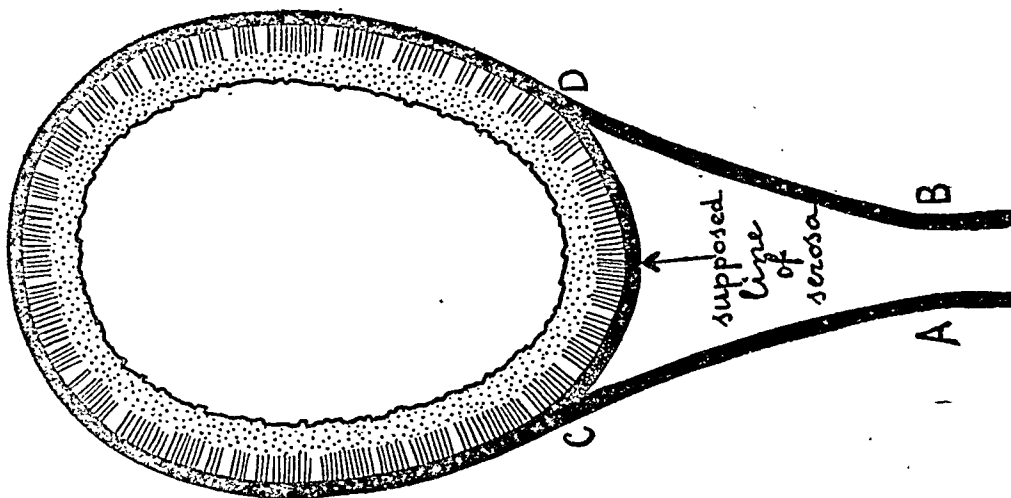
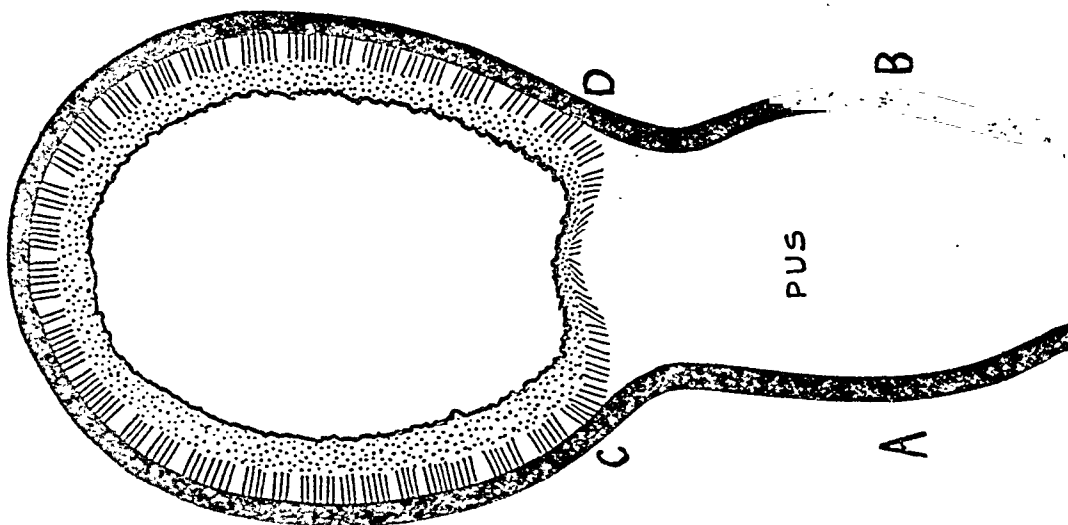


FIG. 4.



FIGS. 4, 5, 6, 7.—The four illustrations 4, 5, 6, 7, show clearly how collections of pus and blood or simple bleeding might become dangerous when met in the mesenteric spaces (mesenteric angles) and how the arrangement of the tissues is providential in preventing danger in most cases. Fig. 4 shows that a collection of pus is formed in the mesenteric spaces distending the tissues in which it has formed. Fig. 5 shows the formation of an hematoma. Pus or blood will leak through the points of minor resistance which is, as shown in Fig. 6, the point found between C and D, because this point is deprived of serosa, and therefore pus or blood will leak into the intestinal cavity. This fact shows the great danger that might come from bleeding at the mesenteric spaces; the blood flowing in tissues that have been infected will keep on leaking into the intestinal cavity and might cause death from hemorrhage. Fig. 7 shows that if the space comprised between points C and D was lined with serosa or if it could be sealed perfectly, pus would in many cases either flow into the abdominal cavity or down towards the root of the mesentery, instead of leaking into the intestinal lumen, because the point of minor resistance would not be almost always the point situated between C and D, as it is actually, but might be the union between the two leaves of the mesentery, or the loose areolar tissue found between them.

because, as it is also known to be an axiom in abdominal surgery, in order to have strong and immediate union and adhesion, serous surfaces must be approximated, the union taking place almost immediately, while the muscularis, submucosa and mucosa do never unite immediately, it takes quite many a day before union between them takes place. We can say that the muscularis, submucosa and mucosa unite only and always by secondary intention, because pus forms always between them and they must heal by granulation. Therefore, accepted as proven the fact that the point of least resistance for the pus to break through is the line comprised between points C and D, it is clear that a collection of pus forming in the mesenteric spaces (angles) will break through line C and D and drain into the intestinal cavity or will leak into it while it is being formed. We can, therefore, state that, although in every case in which end-to-end intestinal anastomosis has been performed, there is formation of purulent material at the so-called mesenteric spaces (angles), this purulent material does not cause any apparent trouble, because it drains through the point of least resistance, which is the line of approximation of the muscularis, submucosa and mucosa comprised between points C and D (Fig. 6), and therefore runs into the intestinal cavity: it runs out into the peritoneal cavity only when the two leaves of the mesentery become at any point the *locus minoris resistentiæ*. This occurs when the mesentery is so damaged that its vitality is decreased to such a point that the union between its two leaves is so hampered as to become less firm than the loose union of the muscularis, submucosa and mucosa of the two stumps of the intestine. The lowered vitality and resistance of the mesentery might result from one or more causes, such as union between mesenteries badly damaged by infection or adhesions, traumata, such as clamping with forceps or other crushing instruments, cauterization with the actual cautery, carbolic acid or any other cauterizing agent, tearing the mesentery with large and wide stitch holes, tying knots too snugly, the presence of blood clots or hæmatomata, the presence of ends of thread hanging out and acting as setons, or large knots between the line of union, which knots keep the two leaves of the mesenteries apart at the point where the knots are and do not allow a close and immediate contact between them, etc. Even when the mesentery has been damaged and its resistance greatly diminished, or ends of threads and knots might favor leakage, leakage does only seldom occur, because luckily the mesentery itself forms immediate adhesions with other peritoneal organs, which adhesions are often sufficiently early formed and dense enough to build up a kind of wall stronger than the loose adhesions between the muscularis, submucosa and mucosa of the gut at points C and D. This walling off of the purulent material and intestinal content does not so often occur when the whole intestine has been severely traumatized or infected by a previous leakage of intestinal content into the peritoneal cavity, such as occurs in perforation of the

gut, if specially, as mentioned before, large knots are left between the two leaves of the mesentery, so that where the knot is the two leaves do not come into close contact, and even more so when ends of any kind of threads, catgut, silk, linen, Pagenstecher are left hanging out, because then they act as real drains leading into the peritoneal cavity the liquid which forms or collects in the mesenteric spaces (angles).

Blood Supply of the Mesenteric Angles and of the Cut Edges of the Intestine.—We have stated that the blood supply of the cut edges of the mesenteric angles is completely shut off and that this lack of blood supply constitutes an element of danger for the union of the tissues forming the mesenteric angles, while the cut edges of the portion of the severed intestine not located in the mesenteric angles are well supplied with blood. As we all know from experimental work made for the purpose of ascertaining the mechanism of union of two segments of gut, that the union is made by the fibrin deposited and organized on and around the cut edges, and that there is a more rapid deposit of fibrin and a more rapid organization of the deposited fibrin the better the blood supply is, we wish the reader to study the blood supply of the cut edges of the intestine after it has been anastomosed by the end-to-end method, as shown clearly in Fig. 3, because this study will make clearer the reasons why leakage occurs more often at the mesenteric angles than at other portions of the anastomosed gut. The illustrations show clearly how the blood is supplied to the gut, after the gut has been resected and properly prepared for the anastomosis. The blood-vessels coming from the mesentery, when they have entered the submucosa of the intestine, anastomose very freely between one another, so as to form a very fine and complicated net of blood-vessels that surround the lumen of the intestine. This free anastomosis of the main blood-vessels coming from the mesentery after they have entered the submucosa and subdivided in many smaller vessels is an arrangement which insures a good blood supply to the intestine, the blood supply of which must be always free and abundant in order to insure the function of the intestine, even if some unfavorable conditions, on which is not the case to insist upon here, should arise. In fact, the blood supply of the intestine is insured even if some of the main vessels coming from the mesentery should be occluded, because the free anastomoses of the finer blood-vessels found in the submucosa insure the blood supply of the portion of the gut, the main blood-vessels of which have been occluded. And this fact is proved by the following interesting experiments: We tied the blood-vessels of a portion of the small intestine close and under the so-called mesenteric angles, so that a portion of the gut of a few centimetres could not have a direct blood supply: this portion of the gut, the blood-vessels of which were tied, did not show any bad effect from the cutting off of its direct blood-vessels; and the reason is very clear if Fig. 3 is carefully examined: blood was supplied to the portion of the gut the direct blood-vessels of which had been tied by

the blood-vessels of the adjoining portions of the intestine on both sides, through the intricate anastomosis of the blood-vessels subdividing in the submucosa. We shall not describe all the experiments made, because they have been undertaken with a purpose which is not directly related to the subject treated in this paper, and they will be published later: we only intend to show that the blood supply of the cut edges of the intestine is excellent, even after the blood-vessels supplying directly blood to them have been tied most accurately. This fact is also proven by the oozing of blood that takes place all along the cut edges of the intestine, after the blood-vessels have been tied at the mesenteric spaces; this oozing from the cut edges has certainly been witnessed by all surgeons, while performing an intestinal anastomosis.

Why Does Pus Formed in the Mesenteric Spaces (Angles) Not Always Run Through the Two Leaves of the Mesentery Up to Its Root?—A point that has still to be elucidated is: why does pus so seldom find its way through the space that exists between the two leaves of the mesentery up to their attachment to the posterior abdominal wall (see Figs. 2, 4, and 6); this space, being made up of loose areolar tissue filled with fat, should oppose little resistance to the invasion of the highly infecting purulent material that is found at the mesenteric angles constantly, as it has been stated above. The reason why pus does only seldom reach the posterior abdominal wall through the two leaves of the mesentery, is the same reason given above; pus will break through the structures that offer the least resistance, pus forming in the so-called mesenteric angles, is formed in a cavity having as its walls above the muscularis, submucosa and mucosa comprised between C and D (Fig. 4), on the sides the two leaves of the mesentery and below the loose areolar tissue filled with fat that separates the two leaves of the mesentery. The side walls of this cavity formed by the two leaves of the mesentery are exceedingly resistant and can stand a great deal of distention without breaking or tearing, as is proved by the immense distention they undergo when an hæmatoma (Fig. 5) or a cyst forms between them; their only weak point is the point where the two leaves of one segment of the gut have been united to the two leaves of the other segment; we have seen, however, that union, and a strong and rapid one, takes place when the precautions mentioned above are taken. The bottom is formed by loose areolar tissue and fat, which, not having been disturbed, forms a solid and compact unity well supplied with blood-vessels in normal condition. The top, that is, the union of the muscularis, submucosae and mucosae of the two segments of the gut, is the weakest part, because, as we have seen, union between the two segments of the gut at that point does not take place until after a certain time has elapsed, so that the pus leaks through it. Only when, by traumata, cauterization, low blood-vessels ligatures, that is, when the blood-vessels are tied far from the attachment of the mesentery to the gut, on account of the presence of hæma-

tomata, or any other agent, the solidity of the tissues which are found between the two leaves of the mesentery is greatly altered, and its blood supply has been abolished or greatly damaged, and especially when the fat has been or shall become dissolved, does the bottom of the cavity become the point of least resistance, and then, and only then, does pus find its way through the two leaves of the mesentery, and if the latter are also damaged, into the peritoneal cavity.

What has been written above explains why end-to-end anastomosis of the small intestine is always and in every case safer than the anastomosis of the colon. The number and virulence of microorganisms increase from the duodenum, which is often sterile, to the jejunum, to the ileum, to the colon, so that the further down the anastomosis is made the less safe it becomes, because the loose areolar tissue is more severely infected and therefore produces purulent material more abundant and more virulent the nearer we go to the anus.

Leakage from Other Points Along the Suture Line.—We have insisted on leakage coming from the mesenteric angles, because leakage from those structures is peculiar to end-to-end anastomosis and not preventable, while leakage from any other points along the suture line is an occurrence common to any suture made on the gastro-intestinal tract and preventable with the employment of a perfect technic, except in the case in which the surgeon is compelled by existing pathological conditions to perform an anastomosis on intestine badly inflamed, infected, or traumatized, or leakage is due to a mistake in dieting, in purging, or to some kind of physical strain. We shall only mention that leakage along the suture line will be due in the great majority of cases to imperfect sutures and to incomplete inversion of the serosas. Imperfect sutures are the ones made with separate stitches, because being impossible to put all the stitches along the same line, if there is any distention of the gut, the stitches which are more taut and are further from the middle line will be put to a more severe strain than the ones that are nearer to the middle line and not so taut, and under the greater strain might probably cut the intestine.

Under the heading of imperfect suture, we must also include: the presence of too many knots along the suture line; stitches that tear the intestine, even in a slight manner; loose sutures which do not approximate closely the serosas, and finally stitches that are too snugly taut, by this we mean those stitches that strangle and cut the tissues: and we have insisted and shall insist on using taut sutures in performing any operation on the gastro-intestinal tract; but by taut sutures we do not mean the sutures that strangle and cut the tissues, but the sutures that approximate closely without tension the tissues that have to be reunited. Other causes of leakage are the great distention which might follow severe traumata or other conditions causing paresis or accidental kinking of the intestine, and in the colon the presence of fæces which, as it

might happen in emergency cases, have not been removed before the operation. We do not insist on these points which are familiar to all surgeons doing good surgery; we shall only mention lack of perfect hæmostasis.

Importance of Hæmostasis.—Perhaps the greatest element of danger in end-to-end anastomosis of the intestine is the flowing of blood from any blood-vessels situated between the two leaves of the mesentery: therefore, hæmostasis between the two leaves of the mesentery must be absolutely perfect. The danger that might result from imperfect hæmostasis is twofold: either bleeding does not stop and the blood flows into the lumen of the intestine, with even probable loss of so much blood as to cause death, as it has occurred in some of our experimental cases and in one case in a human being, controlled by the writer at the autopsy, or the bleeding stops and an hæmatoma is formed (Fig. 5). When an hæmatoma, even a small one, forms between the two leaves of the mesentery the hæmatoma becomes the most favorable ground for the spreading of infection, because blood-clots are perhaps the most favorable grounds on which microorganisms can grow and multiply, and when the hæmatoma is of large size, it causes a distention of the space situated between the two leaves of the mesentery proportionate to its size, and will compress the blood-vessels carrying the blood to the operated area, therefore limiting its already reduced blood supply and causing a blood stasis, which will naturally favor the growth of microorganisms; will compress the loose areolar tissue; will distend greatly the already thin leaves of the mesentery, therefore weakening their resistance, resistance which might be greatly lessened by the sutures used in approximating the mesenteries of both stumps, by clamping, rough handling and other traumata and by infection. When all or some of these elements contribute in weakening the resistance of the two leaves of the mesentery, the leaves of the mesentery might become the *locus minoris resistentiæ*, and therefore any collection of pus that will form between the leaves of the mesentery, instead of breaking into the lumen of the intestine, as it occurs, as explained before, because the union of the mucosa, submucosa and muscularis at the mesenteric spaces is generally the weakest point of the anastomosis, it breaks into the abdominal cavity and all the possible dangers of such an occurrence need only to be mentioned to be appreciated and feared. We think that we have to insist on the importance of perfect hæmostasis of the leaves of the mesentery of both stumps, because its importance is not appreciated as it should be, and not only the hæmostasis must be perfect, but for the same reasons that hæmostasis must be perfect, so that even the smallest hæmatoma should not form, any blood-clot must be carefully removed. Stagnant blood, either as blood-clots or as hæmatomata, is, perhaps, the most favorable ground to be found in the living body on which microorganisms can grow and multiply very rapidly. In fact, the elements constituting the blood have

a great resistance against infective microorganisms when contained in the blood-vessels and circulating, but when they are out of the blood-vessels and therefore not circulating, they not only lose their resistance, but become the easiest prey to all kinds of microorganisms and supply them the means for their growth, such as humidity and the best nourishing media made up by the liquid and organic matter constituting the blood. We stated that a stagnant blood constitutes perhaps the most favorable ground for the growth and rapid multiplication of microorganisms to be found in the living body, and this statement, on the importance of which we insist, is proven by every-day clinical observations: we see that a large hæmatoma is absorbed very readily and with little reaction if it is kept sterile; if, on the other hand, the hæmatoma becomes infected, the reaction is very marked and a general septicæmia is liable to occur, even when the appropriate surgical means have been resorted to, in order to limit the infected area and proper drainage has been applied; the danger is greater the greater the diffusion of the blood in the tissues. It would seem that the blood elements are like fish: they are full of life and resistance while in the circulating system, as it is with the fish in water; when out of the circulatory system they act as fish out of water, they decay rapidly and become the easy prey of any microorganisms with which they come in contact. We insist on these facts, because, as we have proven above, being absolutely impossible to keep sterile the space situated between the two leaves of the mesentery while performing an end-to-end intestinal anastomosis, stagnant blood will be the most favorable element for production of a large collection of pus, which might break into the abdominal cavity; it is now easily understood why we insist so strongly on the most perfect hæmostasis of the space situated between the two leaves of the mesentery and the removal of any blood-clot from the same.

If even a slight hemorrhage or the presence of any blood-clot, or both, constitute the greatest elements of danger in performing an end-to-end intestinal anastomosis, when met in the space situated between the two leaves of the mesentery, they do not cause any trouble if met in the cut edges of the intestine situated above points C and D (Fig. 2), that is, above the points where the mesentery becomes the outer or serous coat of the intestine. The reasons why hemorrhage and blood-clots are so dangerous when met in the space situated between the two leaves of the mesentery, if well understood and appreciated, will show why hemorrhage and blood-clots are less dangerous when met in the cut edges of the intestine situated above points C and D. Hemorrhage there can be only slight, if hæmostasis has been made properly, because by tying at the mesentery the blood-vessels that supply blood to the cut edges, the cut edges will bleed only very slightly, the blood that oozes out of the cut edges coming from the very free anastomosis of all the blood-vessels of the intestine, as shown in Fig. 3, and demonstrated elsewhere in this

paper. The hemorrhage is always very slight and completely controlled by a good mattress suture as will be explained later. Blood-clots which might eventually form on the cut edges are not dangerous at all because they are brought into the lumen of the intestine by the process of inversion of the serosa which is accomplished in performing the anastomosis, and therefore eliminated, as are the ordinary intestinal contents. The best manner of obtaining hæmostasis will be described together with all the other technical points relating to the performance of end-to-end intestinal anastomosis.

Practical Conclusions.—We can immediately draw these important practical conclusions: leakage at the so-called mesenteric angles would not occur if the two external leaves of the mesentery could be reunited in such a manner as to make them adhere immediately and form strong adhesions between them. Therefore, the union of the space found at the so-called mesenteric angles should be accomplished by a means that should approximate, as closely as possible, by inverting them, the external coats of the leaves of the mesentery with the least trauma, and approximate closely but loosely the mucosa, submucosa and muscularis between points C and D (Fig. 2) in such a way as to allow and favor a firm and rapid union between the external coats of the mesentery, that should force any collection of purulent material through the space situated between C and D into the lumen of the intestine; this is accomplished perfectly satisfactorily with the stitch shown in Fig. 13 and paying great attention to all the details of technic which will be described later.

What would happen if the intestine was all surrounded by serosa would also happen if we could seal completely and securely the gut at the upper mesenteric spaces (angles) with serosa. Admitting, therefore, that the upper mesenteric spaces (angles) are infected in every case of end-to-end intestinal anastomosis, we feel justified in having asserted that no technic has been devised, and none will very likely be ever devised, that will make end-to-end intestinal anastomosis really safe in regard to leakage from the upper mesenteric spaces (angles), and we feel justified in making the following statement: End-to-end anastomosis of the intestine would be so unsafe as to have to be considered almost a surgical impossibility if the mesenteric space (angle), which is absolutely indispensable for the passage and protection of the neurovascular system, was not deprived of serosa as it is (Fig. 7), and, if possible, such spaces were completely sealed with serosa by the surgeon, and that the lack of serosa around the intestine, at the so-called mesenteric angles, is a providential arrangement, which allows the performance of end-to-end intestinal anastomosis, instead of being, as it is thought to be, almost a mishap of nature, or, at least, a great obstacle, making end-to-end anastomosis of the intestine difficult and unsafe; the lack of serosa is to be considered as a safety valve that prevents pus from burst-

ing into the abdominal cavity. We can see that the danger that is inherent to end-to-end anastomosis of the intestine is due to the special condition of the tissues forming the mesenteric spaces (angles), because they are filled with tissues that have *per se* little resistance to infection, which resistance is rendered still weaker by the fact that the blood supply of these tissues is completely cut off. So the reason why leakage occurs at the mesenteric spaces (angles) is not because there is lack of serosa around the intestine at those points, but because the mesenteric spaces (angles) are filled with tissues which are positively infected, the infection of which cannot be avoided, and which have little resistance against the infecting microorganisms, this resistance being rendered still weaker by the shutting off of its blood supply.

These conditions are not present in the other portion of the gut, the union of which is greatly favored by the possible complete inversion of the serosas and the excellent blood supply of their cut edges, as we have demonstrated.

We shall now bring forward the points which will help to make end-to-end anastomosis of the intestine as safe as it is possible to make it, and avoid whatever might endanger its safety. We shall describe each single step that will make up what we consider, on the basis of experimental and clinical experience, a perfect technic of end-to-end intestinal anastomosis.

Resection of Gut and Mesentery.—After the surgeon has decided what portion of the gut he intends to resect, clamp with long forceps the portion of the gut and mesentery that has to be removed, placing the forceps at about half a centimetre from the intended line of incision; gently milk back the possible intestinal contents and place a light clamp, or, still better, pass through the mesentery, without tearing any blood-vessels, a light rubber band, or rubber tube and tie it over the portion of the intestine that is going to remain at about five centimetres from the intended line of incision (Fig. 8). Starting from its root, then sever the mesentery up to its attachment to the intestine, opening completely the mesenteric space (angle), but not entering the lumen of the gut. The bleeding vessels are clamped, beginning with the blood-vessels further away from the intestine; that is, the blood-vessels that will be clamped first are the blood-vessels coming from the root of the mesentery. Clamp only the bleeding vessels, without including any other tissue; this will be easily accomplished with a little attention, because the blood-vessels emerge from the loose areolar tissue and fat found between the two leaves of the mesentery (Fig. 9). Proceed then to clamp any blood-vessel that bleeds up to the mesenteric angle. Each blood-vessel that has been clamped must be tied accurately without undue pulling; the tying can be made either with silk or catgut, according to the preference of the surgeon, provided that the catgut or the silk be the finest; plain catgut No. 000 is, according to our experiments, the best material for tying the blood-vessels of the mesentery; the ends of the thread must

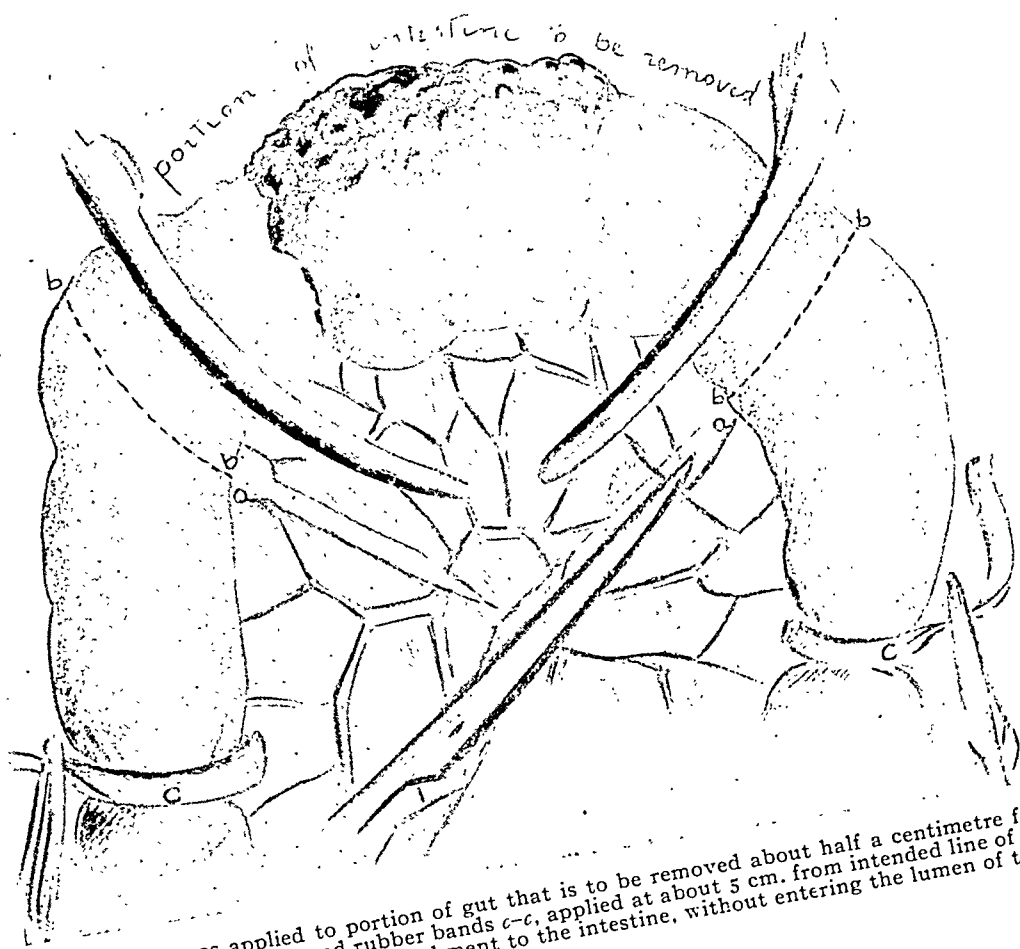


FIG. 8.—Forceps applied to portion of gut that is to be removed about half a centimetre from the intended line of incision, *b-b*, and rubber bands *c-c*, applied at about 5 cm. from intended line of incision. The mesentery is cut *a-a*, up to its attachment to the intestine, without entering the lumen of the same.

END-TO-END INTESTINAL ANASTOMOSIS

be left very short. Abandon for the moment this portion of the gut and do exactly the same with the gut and mesentery at the other side of the part of the gut that has to be removed. The assistant with the thumb and index finger of one hand gently squeezes the portion of the intestine that is to remain close to the line of incision, and with the other hand takes hold of the forceps that have been put on the gut and mesentery (Fig. 10). The surgeon passes a pair of sharp scissors between the gap made in the mesentery and with one single stroke cuts the intestine. The assistant separates immediately the cut portions of the intestine; the surgeon covers the one to be removed with a piece of gauze, which can be kept in place by a Museux forceps and abandons it for the moment

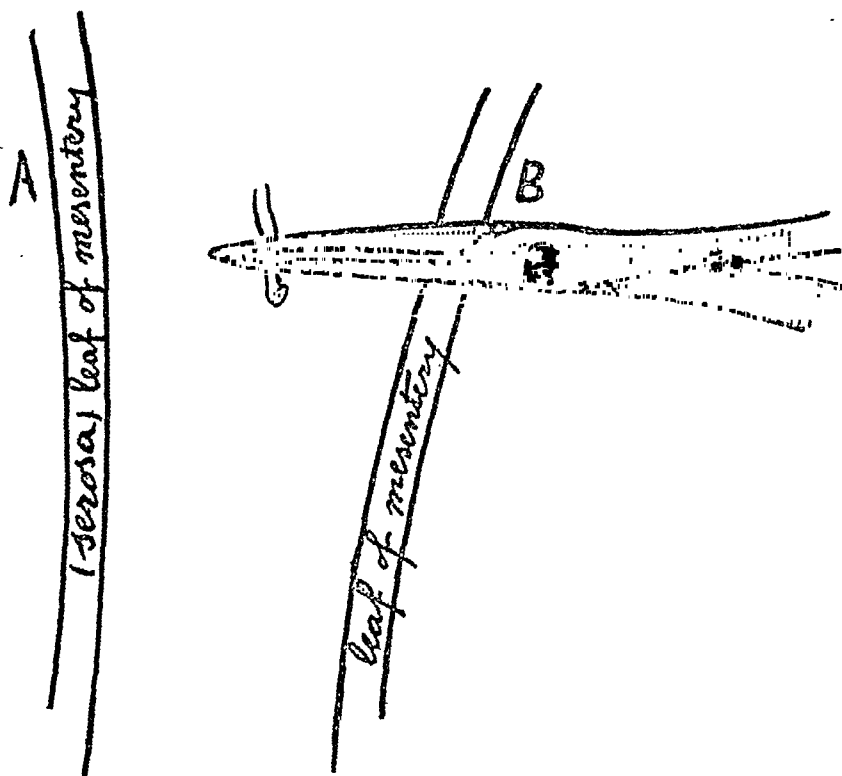


FIG. 9.—Correct manner of clamping and then tying the blood-vessels found between the two leaves of the mesentery, A and B. The blood-vessels have to be clamped and tied without including any other tissue but the blood-vessels.

(Fig. 11). With two thumb forceps he then grasps the cut edges of the other portion of the intestine, so as to keep its lumen open and looking toward the ceiling, the assistant takes off his fingers and with small sponges held on forceps or small sponge holders gently cleans the cul-de-sac formed by the rubber band or the forceps that were put on the gut; he must be careful not to touch the cut edges with the sponges, so as not to unduly infect them; for this reason the sponges must be very small (Fig. 12). When the cul-de-sac has been cleaned, so that nothing leaks out of it, a dry pad made of several layers of gauze is put on the abdomen and the gut is laid on it; another gauze pad is put over the intestine, so that it rests between two gauze pads, and it is abandoned for the moment.

The other portion of the gut is then taken up and severed with the same manoeuvre employed before. The portion of intestine that has to be removed is taken away, severing its attachment to the root of the mesentery, catching and then tying the blood-vessels that might bleed.

The Making of the Anastomosis.—The surgeon begins the suture of the stumps of the intestine at the upper mesenteric spaces (angles); he uses a strand of catgut No. 0, preferably of dark color, threaded on two needles. The choice of the needles is to be left to each surgeon, the ones who are accustomed to work with the needle holder, can use curved needles with the advantage of keeping their fingers clean; we use straight plain mending needles, covering our right thumb and index fingers with thin rubber finger cots, which are thrown away after the anastomosis is made. The upper mesenteric spaces (angles) are closed ideally with the stitch that we shall call mesenteric stitch, shown in Fig. 13. It is begun by passing one of the needles from within the lumen of either of the two segments of the intestine through the whole thickness of the gut and mesentery, traversing the so-called dead space, at a distance of about 3 mm. from the cut edge, avoiding, of course, any blood-vessels. Then the needle is introduced into the other segment of the intestine, on the same side, passing from without in through the mesentery and intestinal wall, naturally traversing the dead space. The needle is then brought out again through the intestinal wall and mesentery, and going back toward the other segment of the intestine is passed through the mesentery and the intestinal wall, coming out in the inside of the intestine at a distance of a few mm. from the spot where the mesenteric stitch was begun. The needles are then brought out of the lumen of the intestine, close to the attachment of the mesentery, so that the threads cross each other, that is, the needle that has been used to make the mesenteric stitch *a* is brought out of the lumen of the intestine a little above the point *r* where the same needle went through the thickness of the intestine and mesentery at the start of the mesenteric stitch. The other needle *b* is brought out on the other side of the same segment of the intestine, also a little above the point where the thread has entered the gut. The illustrations show better and more clearly than any description the very easy manner of closing the mesenteric spaces (angles) with the mesenteric stitch described above. The two stumps of the intestine are then approximated, *and the threads are pulled tightly and parallelly to the line of suture; that is, the fingers pulling on them must not be raised above the plane on which is the intestine.* We beg to call the attention of the reader to the fact that the dead spaces have been traversed four times and that the pulling on the threads closes up completely the mesenteric angles and keeps them closed without putting in any knot. We shall see later the importance of these details. The suture is continued all around the lumen of the gut in this manner (Fig. 13). Either one of the needles enters the serosa of the stump of the other segment of intestine, that is, not of the

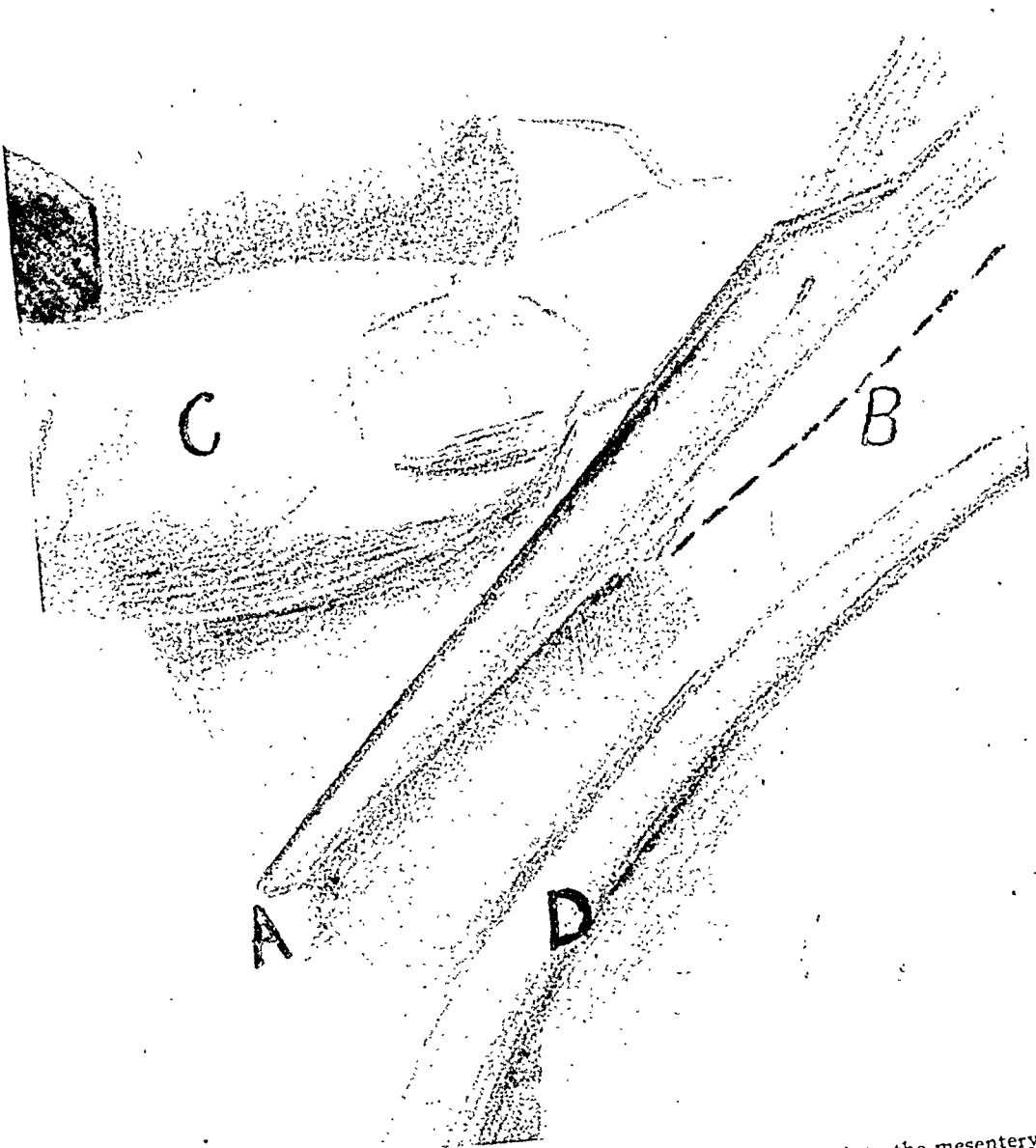


FIG. 10.—The surgeon passes the scissors in the opening already made into the mesentery *B*, while the assistant squeezes between his index and thumb *C* the intestine with one hand and with other takes hold of forceps *D*, and with a single stroke cuts the intestine.

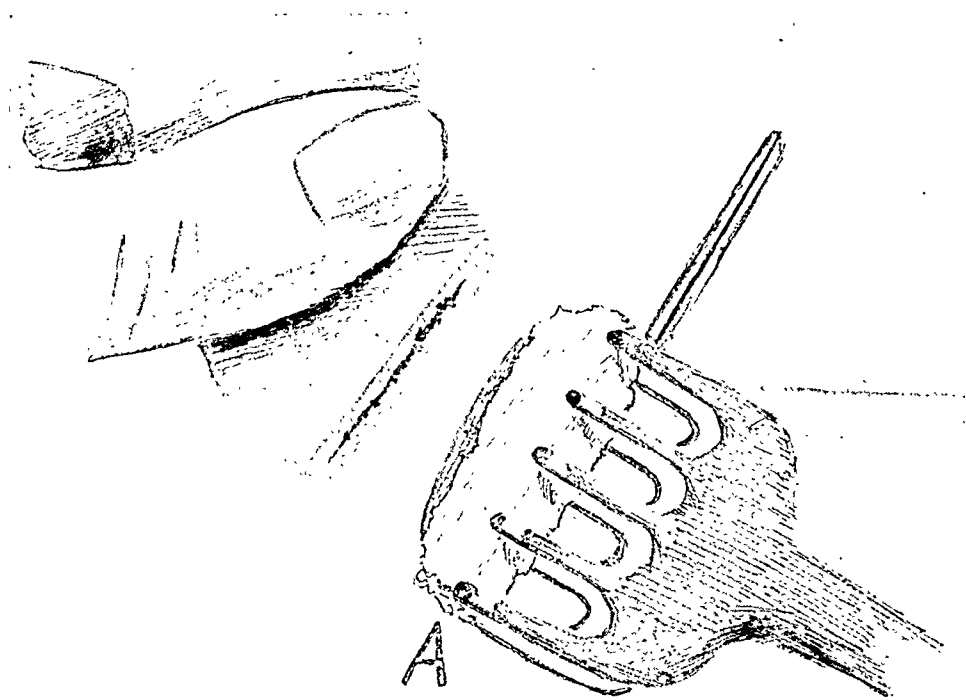


FIG. 11.—Separation of the cut portions of the gut; a piece of gauze covers the cut edge of the portion to be removed, A, and is held in place with a Muzaux forceps.

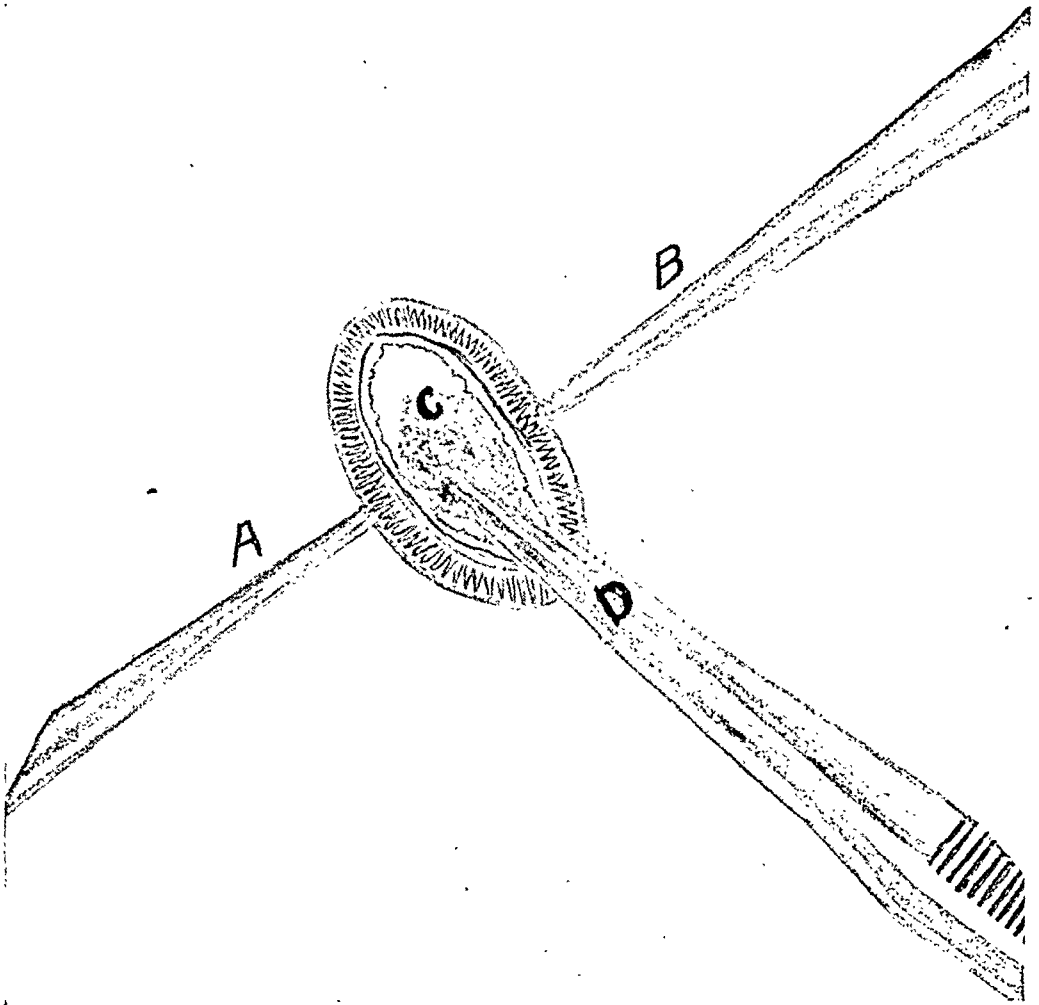


FIG. 12.—Cut edges of gut grasped by surgeon with two thumb forceps while assistant with small sponges, *C*, held on a sponge-holder forceps, *D*, cleans lumen of intestine.

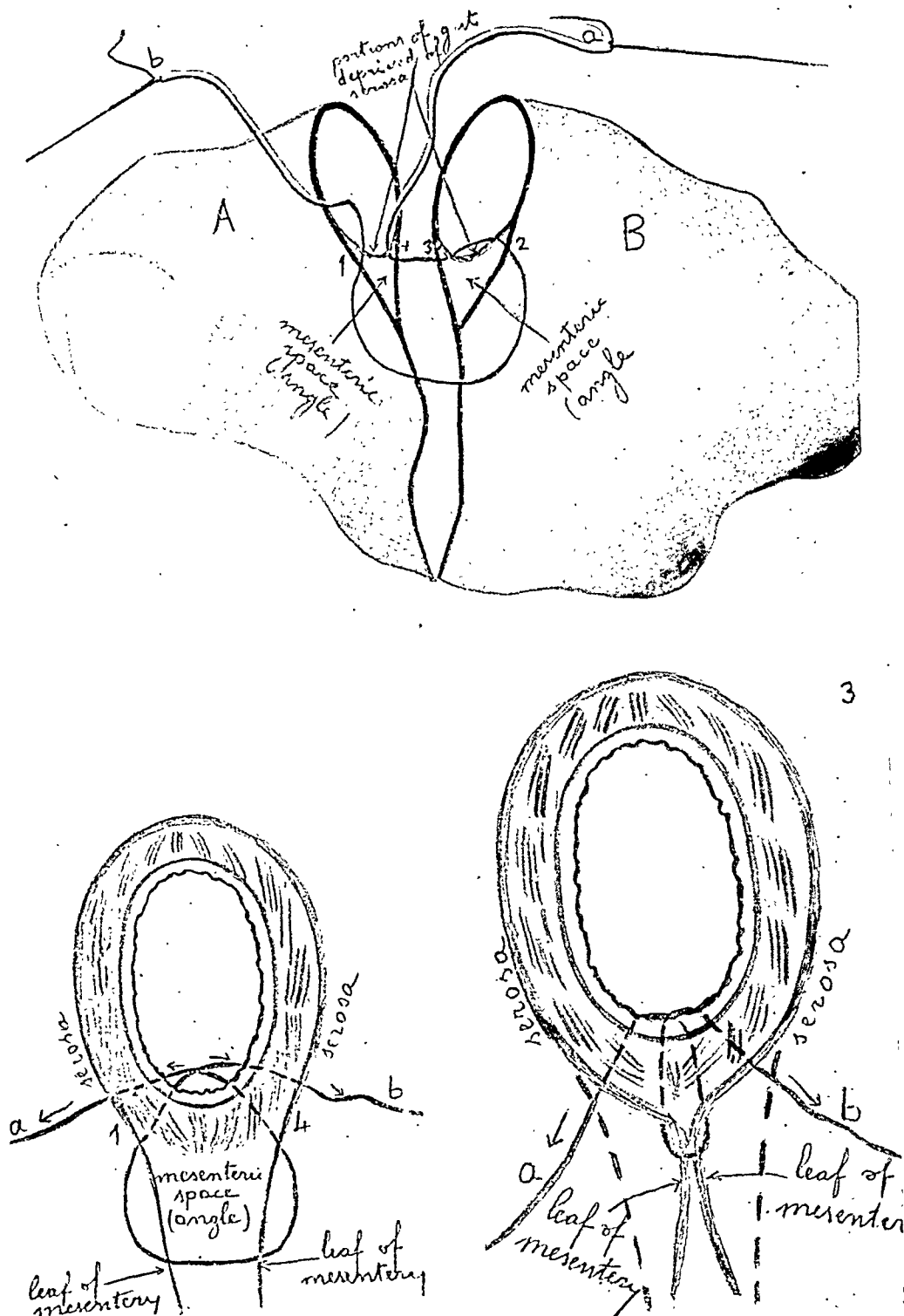


FIG. 13.—Mesenteric stitch. The illustrations show the three steps in which is divided the making and closing of the mesenteric stitch. The first step is made entirely with needle *a*, which starts at point 1 entering the lumen of the gut and coming out on the mesentery, traversing the acute angle made by the mesentery and the portion of the gut deprived of serosa. The same needle *A* then traverses the corresponding acute angle of stump *B* at 2, perforating first the mesentery and then entering the lumen, then it traverses angle 3 perforating first the lumen and then the mesentery, finally it traverses angle 4 perforating first the mesentery and then entering the lumen. The second step consists in making needles *a* and *b* traverse the gut from the inside to the outside a little above of points of entrance of mesenteric stitch, needle *a* coming out above point 1 and needle *b* coming out above point 4. The third step consists in closing the mesenteric space without the use of knots, this is accomplished by pulling threads carried on needles *a* and *b*; dotted line shows former position of the two leaves of the mesentery before threads were pulled, that is, position identical with the position in serosa; note how serosa is well approximated at the mesenteric space, and mesenteric space is closed without undue tension, after threads have been pulled taut.

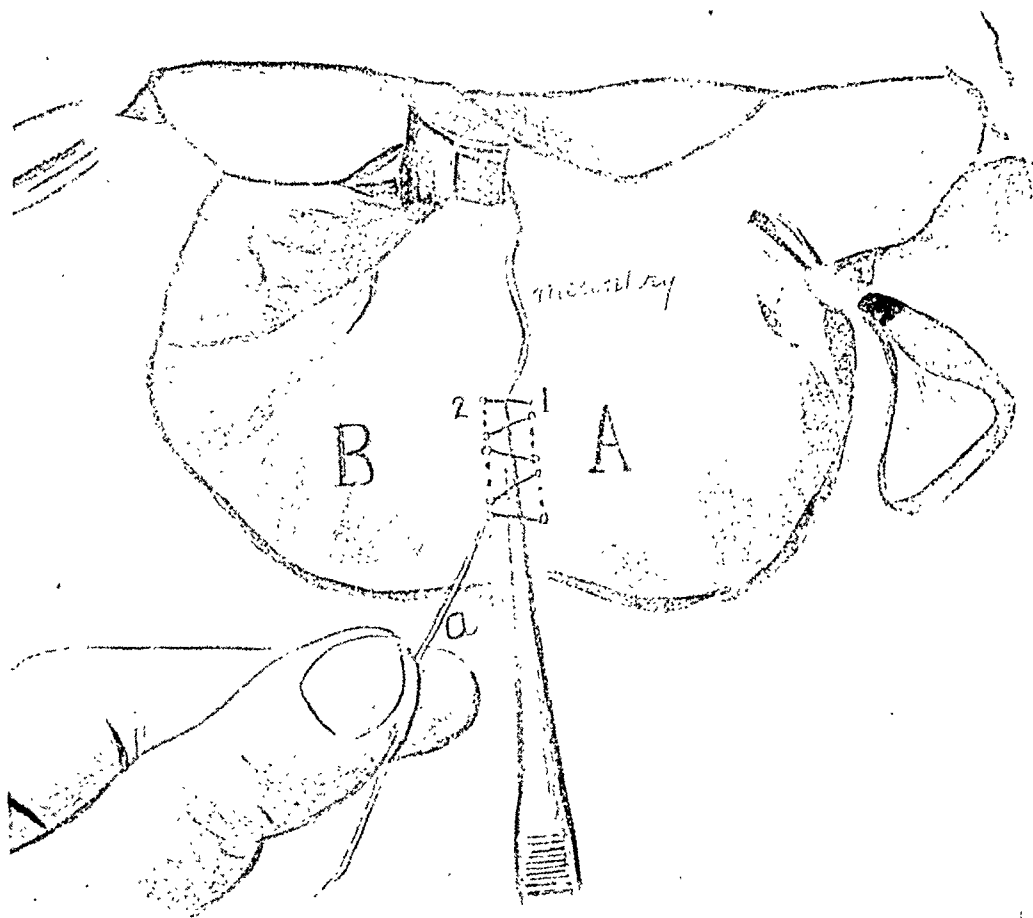


FIG. 14.—Needle *a* that in the preceding illustration after having completed the mesenteric stitch comes out at point 1 on stump *A*, perforates stump *B* at point 2 and closes portion of the gut by means of the special mattress stitch shown in illustration. The thumb forceps shows how inversion of the serosa can be obtained in a perfect manner by pushing inward the cut edges while the thread is pulled taut. The other portion of the gut is closed with needle *b* as explained in the paper, dotted line shows course of needle through the thickness of the gut.

same stump on which it is left after the completion of the mesenteric stitch, but on the other stump; it penetrates the serosa at about three or four mm. from the cut edge, goes deeply so as to be sure to catch the muscularis and the submucosa (Fig. 14), and takes a bite parallel to the cut edge of the intestine of about three mm. It comes out on the serosa and takes a similar stitch on the other segment of the gut entering the serosa close to the point of exit of the mesenteric stitch, and several stitches are taken in the same manner, going from one segment to the other. Each stitch is pulled taut, so as to invert the serosa, which inversion takes place naturally, if the stitches are put parallelly to the cut edges and are taken close to each other; in case the inversion should not take place spontaneously only by pulling the thread, it can be helped by putting a thin forceps under the thread and pulling the thread while the forceps make a gentle pressure on the cut edges of the intestine (Fig. 14). When about half the suture has been made, the needle is dropped and the other needle is taken up and the stitching is continued on the other half of the intestine, exactly in the same manner as the first half. The two ends of the thread should then come out near the top of the intestine, one opposite the other, are knotted, seeing that the knot falls between the line of suture, so as to be buried between the inverted serosa; in order to bury completely the thread under the serosa the ends of the thread should be cut rather short close to the knot. In order to perform a rapid intestinal anastomosis of the intestine by the end-to-end method, that will be easy to make and as safe as it is possible to render safe end-to-end intestinal anastomosis, we recommend still warmly the technic that we described in *Surgery, Gynecology and Obstetrics*, July, 1912. Here we give the technical elements that will make end-to-end intestinal anastomosis a procedure as rapid and as safe as it is possible to make it; elements which are absolutely essential and have been found so in several thousand intestinal anastomoses made with all methods and with the greatest attention to each single detail.

The mesenteries of the two stumps of the intestine are then sewn together in the following rapid manner. The finest black catgut or silk obtainable is used, and beginning from below, that is, from the root of the mesentery, a stitch is put between the two mesenteries and tied, then the needle goes from the mesentery of one segment to the mesentery of the other, taking a bite of about three or four mm. parallel to the cut edge at about three mm. from the same, and proceeds up to the attachment of the mesenteries to the intestine, pulling each stitch and obtaining in this manner an inversion of the cut edges of the mesentery, and burying of any thread that should appear; when the attachment of the mesentery with the intestine is reached the thread is tied and its ends cut short. The same thing is done on the other side of the mesentery. Care must be taken to get through only the most superficial layer of the mesentery with the needle and thread. A still better manner of closing

the mesenteries is illustrated in Fig. 15. It is a shoe-lace suture made with two needles, clearly explained in the illustrations.

Advantages of Technic Described.—Clamping the gut and mesentery that has to be removed is the quickest and safest manner of preventing leakage and bleeding; clamping it at about half a centimetre from the line of incision does not cause any trauma or other injury to the portion of

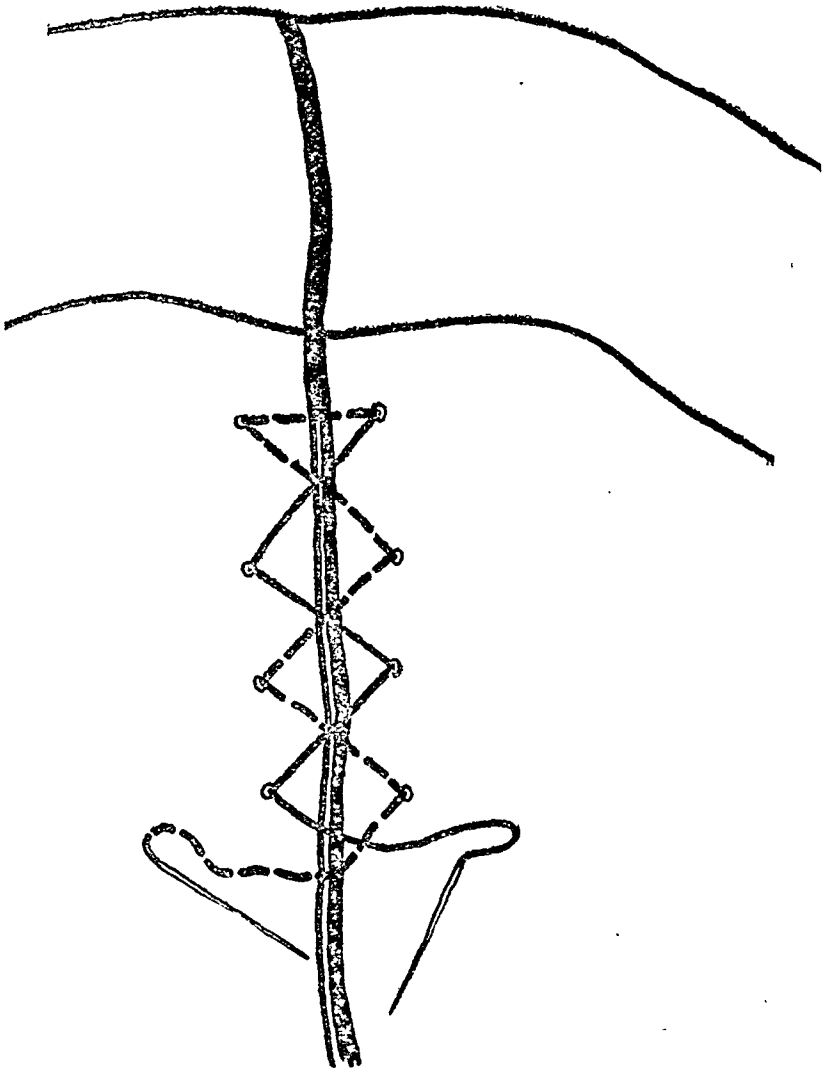


FIG. 15.—Shoe-lace stitch that will close and invert rapidly the two leaves of the mesentery.

the intestine that is going to be left. Milking back the intestinal contents will prevent leakage of the same, when the intestine is severed; rubber tubing or rubber bands have the advantages over clamps that they are not cumbersome and do not traumatize the gut, as it is done by even the best clamps. We put the rubber tubing at about five centimetres from the intended line of incision and not further, because it is easy to milk and then clean five centimetres of gut, while it would be more difficult to milk and clean a longer segment, and five centimetres give sufficient room for

a rapid accomplishment of the anastomosis. Opening the mesentery from below upward prevents avoidable infection of the same, especially when it is done with the same instrument that is used to open the intestine. The bleeding vessels are caught, beginning with the ones that come from the root, because as long as the blood-vessels come from the root of the mesentery, it is more logical to tie first the main ones, and, only if necessary, tie also the branches which might not bleed when the main vessels are tied, and therefore have the advantage of saving some time by not doing unnecessary ligatures and leaving less foreign bodies. We recommend to catch only the bleeding vessels, which is easily done if the surgeon is attentive and careful, because including in the clamps, and after in the ligature, other tissue is not only unnecessary, but will favor sloughing of these tissues, which sloughing will favor the formation of abscesses, as infection always occurs, and given the little resistance and vitality of the tissues found between the two leaves of the mesentery, as explained elsewhere. We recommend the finest thread, because it is obvious that, at least, it is useless to employ heavy thread where a fine one will suffice, and catgut No. 000 is recommended because strong enough and easily absorbed. The ends of the thread must be cut very short, because they should not hang out of the line of suture, with the probability of forming a kind of seton that would carry infectious material in the general peritoneal cavity.

The technic of severing the intestine, as we have described, insures in the best manner cleanliness and rapidity; no infectious material is spread anywhere; the only element necessary for a rapid and clean work is the intelligent coöperation between surgeon and assistant.

We recommend for the end-to-end intestinal anastomosis only one row of sutures; many thousand intestinal anastomoses made for experimental purpose and clinical experience have proven to the complete satisfaction of all who have witnessed our work that one single row of sutures is sufficient to insure a good anastomosis; we do not insist here on the advantages of the technic described by us in the paper already mentioned, that technic was proven always satisfactory, because safe and most rapid, even more rapid in the hands of men trained in its use, than the anastomosis made with the Murphy button. As we have explained the advantages of the method in the paper already referred to, we beg the reader to read it again if more details are desired. Here we shall only insist on what we consider the essential elements for a rapid and safe end-to-end intestinal anastomosis. One row of sutures is recommended because the union which takes place between the serous surfaces takes place independently of any suture; as long as the serous surfaces are approximated closely and lightly irritated, they adhere immediately, the adhesion becoming stronger, not on account of any suture material which has been put in, but by the organization of the fibrin deposited on the line of union. And, in fact, Murphy used his button

without putting any re-enforcing serous suture and obtained firm and strong unions, although the tissues engaged in the button and tightly approximated do slough away very rapidly. With one row of suture, as advised above, we approximate closely the serous surfaces (Fig. 16), which being irritated by the trauma of passing the needle and thread and the consequent light infection, react and in reacting produce an irritation of the serous surfaces resulting in a localized adhesive inflammation of the serosa, inflammation which will be localized only along the suture line (Fig. 16 *a*), if the technic advised above is followed carefully, in this way avoiding the formation of undesirable adhesions.

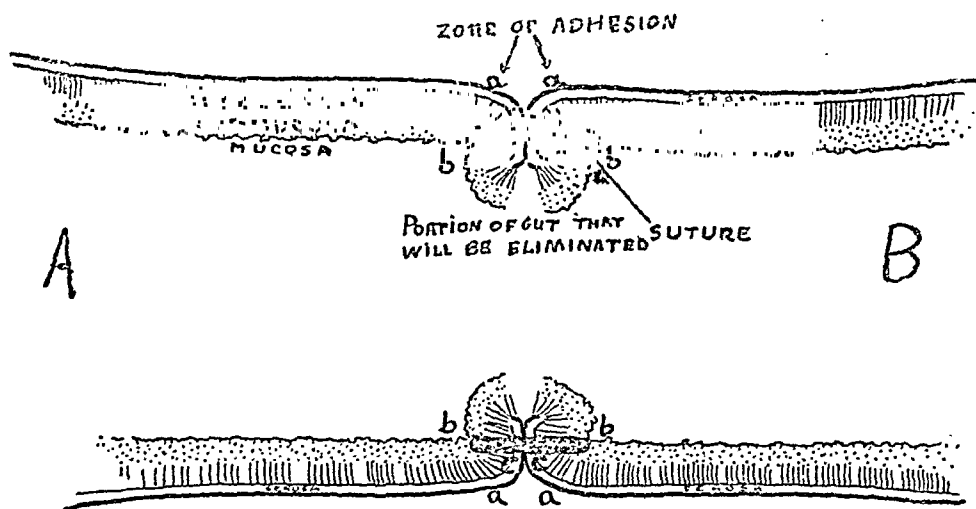


FIG. 16.—Schematic view of how one row of mattress suture inverts and approximates the serosa of two stumps of intestine A and B anastomosed by the end-to-end method, and of mechanism of union between the inverted serosas. If the suture is kept taut after having inverted the serosa we see the following features: the suture has traversed the cut edge of the intestine and therefore infected the serosa at points *cc*, at which points the serosas of both stumps A and B come in close contact; the suture being taut will deprive of blood supply the portion of the cut edges which is below the suture itself, in the illustration this is marked by *b* and *b*, and this portion of the cut edges will slough off and fall in the lumen of the intestine; the hold of the suture on the tissues being limited to the time that it takes for the tissues below points *b b*, to lose their vitality and slough off. Above points *cc* the serosa of the two stumps of intestine is brought in close contact, is irritated and infected by the passing of the needle and thread and will set up a localized area of inflammation, so that fibrin will be deposited in the hollow formed by the inversion of the serosa *a a*, which fibrin will seal up the line of anastomosis when the suture, on account of the sloughing of the tissues below points *b b*, gives way. The final zone of strong adhesions formed between the two stumps of the intestine when the fibrin is organized will be limited to points *a a*, and *cc*, and will not narrow to any considerable extent the lumen of the gut.

Mechanism of Union Between Serous Surfaces.—We beg to be allowed to insist on the mechanism of union between serous surfaces, because it seems to us that it is generally not well understood. Union between serous surfaces takes place always and only through an intimate process of reaction of the serous surfaces that come in contact; when any serous surface is irritated by any cause, trauma, infection or whatever it might be, it reacts more or less violently according to these two principles: it reacts more violently the more serious and violent the irritating element; it reacts more violently the more vital the irritated peritoneal surface is. If we apply these principles to the mechanism of union between two stumps of intestine reunited by the end-to-end method, we shall easily see that the technic we have advised will make end-to-end anastomosis

of the intestine as safe as it is possible to make it. We have to approximate closely the serous surfaces, we have to preserve as much as possible the vitality of the intestine especially along the suture line. With one row of sutures as advised by us, do we approximate very closely the serous surfaces? By taking the stitches parallelly to the cut edges and very close to each other at about three mm. from the cut edge and pulling the thread very taut, we obtain an inversion of three mm. (Fig. 16) of the serous surface of each stump of the intestine and a most intimate and close approximation of the serous surfaces reunited by the stitches, which being put close to each other and parallelly to the cut edges (Fig. 14) reunite, when the thread is pulled taut, the serous surfaces so intimately and closely along the suture line that they appear to be glued together (Fig. 16). The irritation caused by the passing of the needle and thread will set up a reaction from *cc* to *aa* (Fig. 16), and if the stitches are close to each other, the points of reaction will be so close to each other as to merge one into the other, making a continuous line of reaction all along the suture line. Not to be neglected, although it is wrongly feared by the surgeon, is the element of infection in setting up a very helpful reaction all along the suture line. We have recommended to take the stitches very deep, so as to be sure to take in the muscularis and the submucosa; we add that the surgeon has not to fear to enter the lumen of the intestine, because the infection carried with the thread is not only not dangerous but will also help in making the anastomosis safer, instead of being an element of danger, as it is wrongly thought, provided certain conditions, that we shall mention, are not neglected. In fact, if the thread enters the lumen it will be infected; at each point of emergency of the thread on the serous surfaces there will then be a point of strong reaction, *cc* (Fig. 16), because the serosa has been irritated by the passing of the needle and thread and the infection carried by them, if these points of reaction are close to each other and the thread is taut we shall have a continuous line of serosa which reacts rather strongly and will therefore set up a localized inflammation of the serosa which will seal up completely with a deposit of fibrin the line of union of the two stumps of the intestine that have been anastomosed; when the fibrin from *aa* to *cc* (Fig. 16) is organized we shall have a strong union between the two stumps of the intestine that will insure the gut against any leakage. Naturally the stitches must be taken parallelly and close to each other and to the cut edges and kept taut in order to obtain a continuous line of reacting serosa, which shall form a smooth, even, continuous line of union later. And we feel that we must insist on another very important point in regard to union between serous surfaces; in the first three days after the anastomosis is made leakage of intestinal contents cannot take place if the suture has been properly performed, *because the suture properly placed does prevent any leakage on account of the close approximation of the cut edges*; if leakage occurs in the first three days,

the fault might be all with the surgeon, because he has either sewn up portions of intestine so badly damaged that they did not hold the suture, or he has not put in a good suture, more often and mostly because the stitches were either too loose or too taut, and this will occur specially when the intestine is sutured with separate stitches, or the general condition of the intestine made suturing of the same very precarious. To prove this assertion any surgeon has to perform an intestinal anastomosis or a gastro-enterostomy on a dog and then, closing on one end, either the stomach or the intestine, tie the other end on a large syringe or on the water faucet and allow the water to fill them and have them rather distended by the pressure of the water inside the lumen; if water leaks through the suture, or the line of suture breaks at some points, it means that the suture was not well made and leakage or breaking will occur specially when separate stitches have been used or the serosa and muscularis has been badly damaged by pulling the thread in directions not parallel, as we advised, but against the tissues that have been sewn up, just as a wire or a thread is pulled against the cheese in order to cut it. If a continuous mattress suture with close stitches, as we have recommended, has been used and the stitches have been kept taut, no leakage whatsoever will occur and would therefore not occur in a stomach or in an intestine sewn up in the same manner, after a real surgical operation had been performed on them, for about three days. After three days the tissues included in the suture (Fig. 16) begin to slough off *bb*, and, therefore, the hold that the suture has on the tissues is getting weaker every day, until after the fifth or sixth day it is absolutely nil and therefore the union is as strong as the fibrin deposited on the line of union between *aa* and *cc* (Fig. 16) makes it; therefore, the more fibrin there is, the stronger and safer will be the union and the more fibrin there will be the better is the blood supply and healthier the tissues reunited. It follows, then, that any anastomosis made between the stomach or the intestine will be, when properly executed, strongest the first day after it is made, become weaker up to the fifth or sixth day, at which time it will be weakest, and then gradually get stronger, until after fifteen or twenty days it is really very strong. It follows, therefore, also, that the idea of purging or feeding patients only after five or six days, that the stomach or intestine has been sewn up, is absolutely wrong, because then the surgeon puts a great strain on the line of union at the very time that this union is weaker. Our practice is to feed patients operated on the gastro-intestinal tract as soon as possible after the operation; we give them twice a day paraffin oil in order to lubricate the bowels continuously, and we do not allow them to have their bowels move violently for at least two weeks; their stools are facilitated only with oil enemata, and are allowed only in the recumbent position on a bed-pan while in bed; these precautions are naturally more important when the colon has been sutured. It follows, also, that the anastomosis has always to be per-

END-TO-END INTESTINAL ANASTOMOSIS

formed on gut the circulation and vitality of which are absolutely good; otherwise the failures should not be thought to be due to the special method followed in performing the anastomosis, but only on the poor judgment of the surgeon, who has not selected the proper portion of the gut, that is, he has either selected a portion of the gut the circulation or the vitality of which was poor, or unfortunately has to deal with a patient whose peritoneum could not react properly, as it happens when a general peritonitis is present and the surgeon is compelled to perform a resection and successive anastomosis of the stomach or of the gut; in these cases we would advise, when time is not the most important consideration, not to resort to end-to-end anastomosis of the intestine, but to the side-to-side, or better, to the oblique anastomosis. From what we have stated above, we can also see how important it is to preserve as much as possible a good blood supply to the stumps of the intestine that have to be anastomosed. We believe that the blood supply is preserved, as well as it is possible to preserve it, if the technic that we have advised is followed, because only the vessels that do actually bleed are tied so that the blood-vessels can carry a very rich blood supply to the stumps of the intestine up to their very edges, as shown in Fig. 3.

We select catgut No. 0 because it is absorbable material and as we have proved in another paper,¹ it is not safe to use unabsorbable material on the stomach or on the intestine, when the suturing material enters the lumen, because it might not be eliminated and might become the centre of ulcers or of calculi (Fig. 17), which can even completely obstruct the lumen of the intestine. In the technic recommended by us, where the suture is done over the special rubber tube, we recommend silk because it is always eliminated with the tube, but when that technic is not followed, catgut must always be employed for any suture that might enter the lumen. Catgut No. 0 is recommended for any intestinal anastomosis, because it is fine, therefore does not tear large holes in the serosa which might cause adhesions with other peritoneal organs, and being sufficiently strong for any intestinal suture and lasting at least from ten to fifteen days, will positively hold the stump of the intestine together until strong adhesions have formed. We recommend catgut of dark color, because it shows clearly the suture is well performed. We stated that no suturing material should be seen when the stitches are properly placed and are kept properly taut, so that they approximate closely and securely the serosas; it is easy to understand that suturing material of dark color will show itself much more plainly than the ordinary plain catgut, which is of about the same color as the tissues that have been sutured and gets confused with them; therefore, it is more probable that a suture might result to be loose when suturing material of neutral color is used than when suturing material of dark color is employed. And we insist on

¹ Soresi: *ANNALS OF SURGERY*. Secondary Ulcers of the Stomach and Intestine, March, 1915.

recommending that any suture made on a peritoneal organ should always and in every case be very taut; the suture has to approximate very closely serous surfaces, so that they shall adhere between themselves; the closer the union the more rapidly will adhesions form. The stitch that will approximate best the serous surfaces is the mattress stitch that we have described, because the line of union is made with one single thread, that when taut will form almost a straight line parallel to the line of union, in this manner holding the surfaces that have been sewn up closely approximated and without any tension, because the tension is distributed and balanced all along the suture line. But we must insist on a most essential point, that is, on always keeping the suture taut, and this is best and most easily accomplished by using thread of dark color, which will show itself very plainly between the surfaces that have been sewn together if the suture is not taut. We recommend the special mattress stitch that we have described because if accurately made it is not only the most rapid manner of suturing the serosa, but it is the safest; it does approximate the serosas so perfectly that they seem glued together (Fig. 16). The special stitch, that closes the mesenteric angle, we believe to be the best method of closing it; in fact, it closes completely the dead spaces and then holds them closely together without any undue tension; the serous surfaces are closely approximated, but there is no tension anywhere and the dead spaces are closed but not too tightly, so that any purulent material that should form in the mesenteric angles can leak immediately into the lumen of the intestine, because the union of the serous surfaces which are closely approximated is always, from the very first moment that the anastomosis has been made, stronger than the union of the tissues above the mesenteric angles, which were only loosely approximated and will heal by granulation. Another great advantage of the stitch recommended for the closure of the mesenteric angles is that it is not only very quickly made, but is safer than any other stitch, because it does not leave in the mesenteric space any suture material but the threads that pass through them. The importance of not leaving any foreign material in the mesenteric spaces has been already emphasized, and we shall here only mention the importance of avoiding as much as possible the presence of knots along any suture line made in the peritoneal organs. In a great number of experiments made, we have found that after a gastro-enterostomy or an intestinal anastomosis has been performed, the weakest points of the line of suture are the points where there are knots; we have proceeded in this manner in order to study the strength of different sutures. We have resected the gut that had been anastomosed or the stomach and intestine on which a gastro-enterostomy was performed at the intervals of from six hours up fifteen days after the operation had been performed, and after having tied one end, water was forced through the other until the stomach or the intestine bursted; we have found that very often, that is, when the

END-TO-END INTESTINAL ANASTOMOSIS

suture was perfectly made, the stomach or the intestine would burst not along the suture line but somewhere else up to twenty-four hours after the operation had been performed; after twenty-four hours, water would always leak through the line of suture and always at the points where the thread had been tied, and therefore a knot was present; we came to the natural conclusion that the point where there was a knot was the weakest of the whole line of suture, and therefore we tried to avoid the putting of knots when knots can be dispensed with, and we have devised the technic of making the intestinal anastomosis with just only one knot that is absolutely indispensable, and we tie it away from the attachment of the mesentery, that is, as we shall explain later, we tie it where the circulation is the best. So we cannot too strongly warn the surgeon against the use of separated stitches, which not only require so much more time, but which have many disadvantages. The line of suture is never absolutely even, because it would be impossible to put all the stitches at the same distance from each other; the tension on the line of suture is not evenly distributed, because it would be impossible to put the exact tension on each individual stitch; therefore, each stitch will work individually, with the result that if any tension is made on the suture line the tension will not be borne by the suture line as a unity, but by each individual stitch, some of which will be more taut than others and therefore will tear the tissues. From our numerous experiments we can positively state that the suture we have found to be the strongest is the one we have described, and the anastomosis made with just one row of sutures, as we have described, was found always to be far much stronger than the anastomosis made with any other method and with two or three rows of sutures from twenty-four hours up to any time after the sutures were made. As the suture we have described is also the most rapid, because the surgeon has to tie only one knot, does not have to change needles and thread, and can do the suturing very rapidly, we feel that there is absolutely no utility in resorting to sutures more complicated, not so strong, not so safe, and requiring more time. By putting the stitches at about three mm. from the cut edges, we obtain an inversion of about three mm. of serosa which is absolutely sufficient to insure a perfect sealing of the line of suture, and by putting the stitches close to each other we obtain a close union of the serosa without any pocketing or ruffling of the same, so that the line of suture appears as a straight line and, as said before, the two stumps of the intestine appear not sewn but glued together. We make about half the suture with each needle, because suturing with two needles makes the suture more rapid and easy, as it is more handy to sew from the mesentery to the top of the intestine, and because we do want to make the knot far from the mesentery. We have written that knots are the weakest point of the suture, therefore, we want to put the only knot where it might do less damage; that is, we have to put it where the tissues are best supplied with blood and we

believe that the points less supplied with blood are the points nearest the attachment of the mesentery to the intestine and therefore we make the knot away from them. In fact, it is sufficient to look at Fig. 3, which represents splendidly the circulation along an intestinal anastomosis made by the end-to-end method, in order to see, as clearly as daylight, that the idea held by many that the circulation along the border of the mesentery is best, because the blood-vessels come from the mesentery, is absolutely wrong. In fact, the picture shows clearly that the blood-vessels are all obliterated at the mesenteric angles and that therefore the circulation there is practically nil, while above the mesenteric angles the circulation is very good, because the blood-vessels anastomose so freely between themselves that they form a very intricate net of blood-vessels, which insures a good circulation along the cut edges. We do not, therefore, advise to tie knots along the mesenteric borders, but far from them.

If the stitch we have recommended is made carefully, inversion of the serosas takes place very easily and spontaneously; if this should not occur, the inversion is easily accomplished by gently pressing on the line of suture with a thumb forceps; we insist, however, that the inversion is essential to a good anastomosis; along the suture line no mucosa should be seen. We repeat again, an end-to-end intestinal anastomosis can be made very rapidly (about four or five minutes) with the technic we have described, but requires some surgical skill easily acquired by any one with enough surgical sense to enable him to do good general surgery, but the essential points on which we have insisted must not be neglected; they are all essential to make end-to-end intestinal anastomosis of the small and large intestine very rapid, easy of performance, and as safe as an end-to-end intestinal anastomosis can be made; the essential points are: Absolute hæmostasis between the two leaves of the mesentery, using the finest catgut or silk; good closure of the upper mesenteric spaces (angles), perfect approximation and inversion of the serosas all along the suture line, without any thread sticking out between the borders; avoidance of knots. All these points are essential, must not be neglected, and are not if the technic described is followed literally.

The only knot we use in our suture buries itself between the inverted serosas, if it is tied between them and the ends are cut short. Naturally, it would be better not to use any knot, but putting the knot as advised by us lessens to practically complete safety the dangers that might lurk in the presence of the knot.

The two leaves of the mesentery are then sewn up on both sides with a running stitch, because in this manner their cut edges are also inverted, so that we obtain a continuous line of serosa from the root of the mesentery up to all around the intestine; we recommend the running or the shoe-lace stitch described by us, because they are very quickly applied and invert the cut edges better than interrupted sutures which require a great deal of time. We recommend also to take a very superficial bite

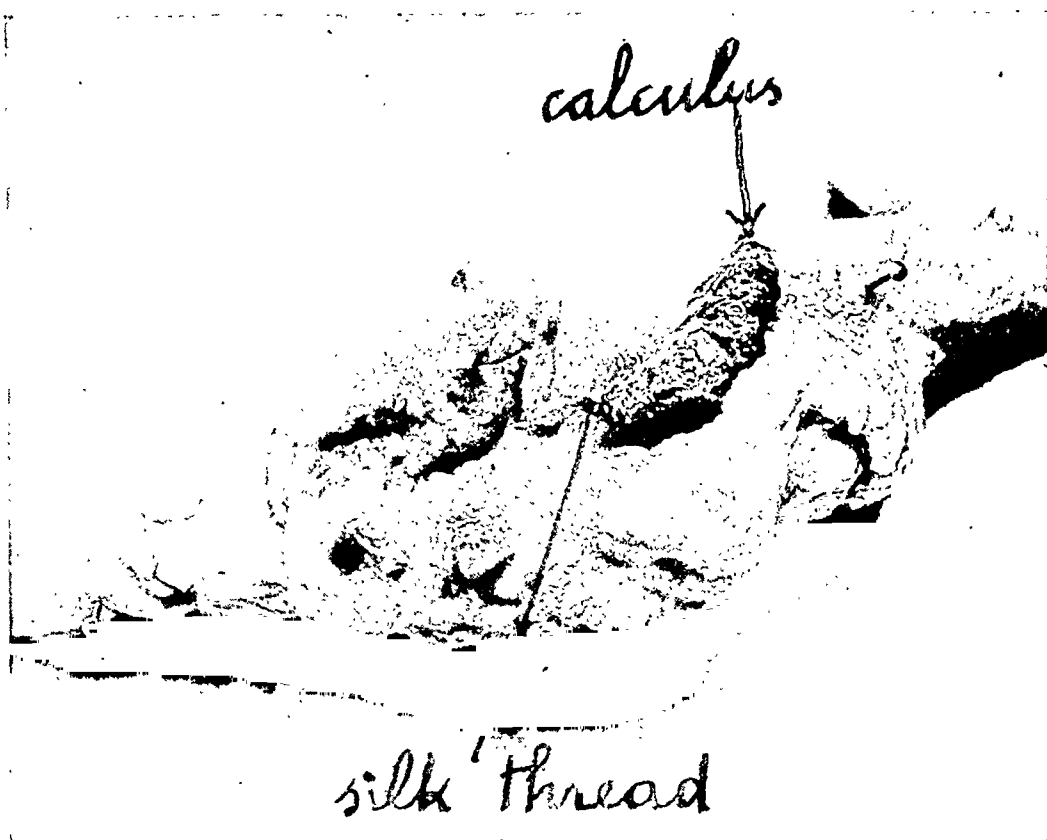


FIG. 17.—Showing a fecal calculus formed around a silk thread that was used in performing an anastomosis of the intestine.

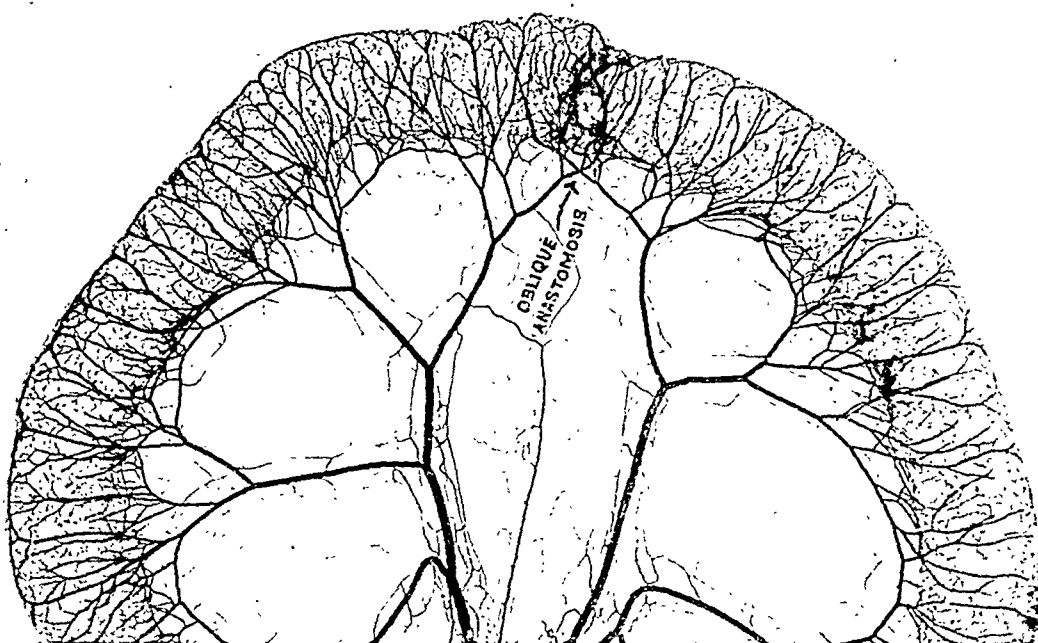


FIG. 18.—X-ray picture of circulation in a portion of intestine on which an anastomosis by the author's oblique method has been performed. Note that where the gut has been anastomosed the circulation is much more abundant than in any other portion of the intestine. The liberal supply of blood all along the line of anastomosis explains why the anastomosis made by the oblique method is much safer than the end-to-end.

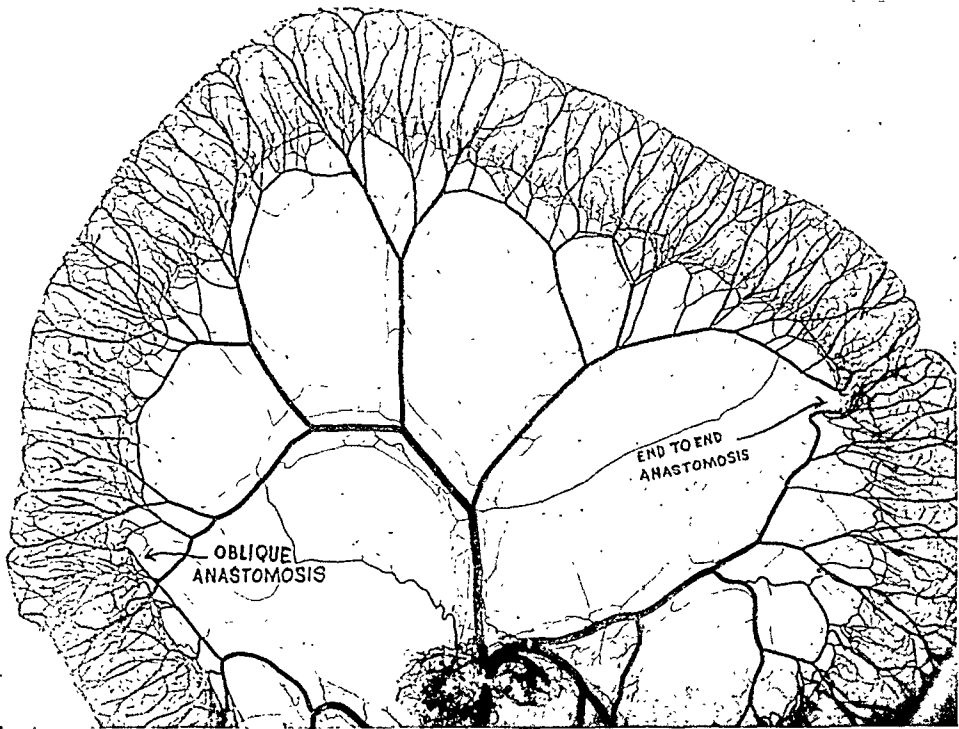


FIG. 19.—The X-ray picture of a loop of small intestine on which two anastomoses have been made, one by the end-to-end, the other by the oblique method is presented, in order to afford a comparison between the status of the blood circulation along the line of suture and especially at the mesenteric space (mesenteric angles). As shown in the other two pictures Figs. 3 and 18, the circulation of the intestine where an end-to-end anastomosis was performed is much poorer than the blood circulation of the portion where an oblique anastomosis has been done; compare specially the points marked with an arrow that indicates the status of the circulation at the mesenteric spaces, which is *nil* where an end-to-end anastomosis has been performed and very abundant where an oblique has been done.

with the needle, because in this way there is no danger of perforating any blood-vessel, and it is not necessary to go deeply, with the idea of making the suture stronger, because the suture is strong enough even if only the most superficial layers are interested, the mesenteries not having to undergo any pulling and adhesion between the serosas sewn together taking place very rapidly. *The mesenteries of the two stumps of the gut that have been anastomosed must always be sewn together in order to avoid a hernia that might form if the gap is left open.* As we have stated, end-to-end anastomosis of the intestine would be always safe, as far as leakage from the upper mesenteric spaces (angles) is concerned, if the leaves of the mesenteries of each stump should form rapid and strong union, because the purulent material that forms in the upper mesenteric spaces (angles) would always leak through the loose union of the mucosa, sub-mucosa and muscularis of the intestine, which, as we have stated, is the weakest point along the line of anastomosis. With the technic that we recommend we invert the cut edges of the mesentery, which have, as we have proved, no blood supply, and approximate the serous lining of the mesenteries away from the cut edges, that is, from points where the blood supply is still good, and so we facilitate their perfect union and so also prevent adhesions between the sewn mesenteries and other abdominal organs.

When performing end-to-end intestinal anastomosis, we do not advise the cutting away of any portion of the gut with the idea of making it wider, or of rendering the anastomosis safer; end-to-end anastomosis of the intestine has to be resorted to only when the anastomosis has to be performed in a great hurry, and the placing of special stitches, cutting away of mucosa, of portions of the cut edges complicate so much the operation that its performance requires more time than the performance of the oblique anastomosis described by the author in *Surgery, Gynecology and Obstetrics* and in *Policlinico*,² and which is the safest manner of anastomosing the gut. We refer to our papers on the subject and only show pictures of the general cut line of the disposition of the gut and its blood-vessels, that give to the reader an idea of how safe and rapid the method is (Figs. 18, 19, and 20).

End-to-End Anastomosis of the Colon.—A special mention should be made of the anastomosis between the small intestine and the colon, and between two stumps of the colon. The surgeon feels always more uncomfortable after the performance of an intestinal anastomosis in which one or both stumps belong to the colon than when both stumps belong to the small intestine. We have given already the reasons why anastomosis of the colon presents more danger than anastomosis of the small intestine, and we believe that Mummery is right when he states that side-to-side anastomosis of the colon or of the colon and small intestine is

² Soresi: A New Method of Lateral Anastomosis. *Surg., Gyn. and Obst.*, February, 1915. *Anastomosi intestinale obliqua. Policlinico, Surgical Section*, November, 1918.

not to be recommended, specially on account of the long time required, the two pockets resulting from the closing of the two stumps, and because it is not possible, in every case, to loosen sufficiently and safely the two stumps that have to be overlapped. We do not agree, however, with Mummery when he states that the top of the gut should be resected because it is not well supplied with blood. The reason he gives for this supposed poor blood supply of the top of the gut is that the blood-vessels of the colon run parallelly to each other and do not anastomose freely. We do not contest the fact that the blood-vessels do not anastomose as freely as the blood-vessels of the small intestine, but we do believe that the blood supply of the colon is better far from the attachment of the mesentery than near it. What we have written above proves

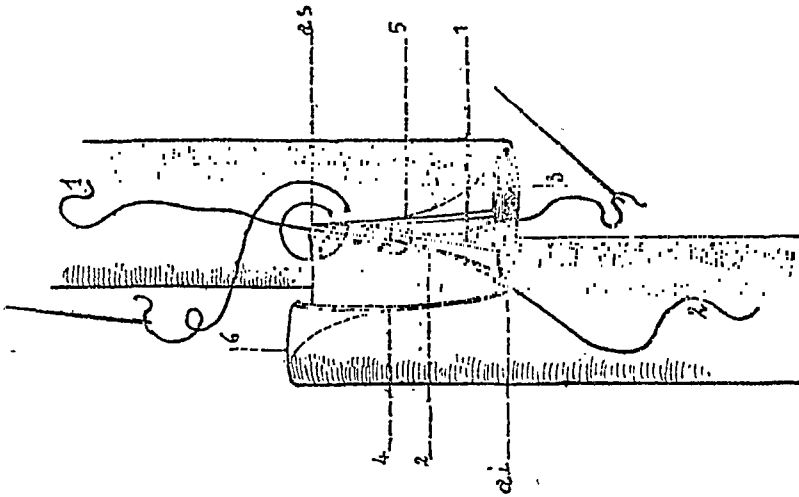


FIG. 20.—Disposition of the two segments of the gut when they are going to be anastomosed by the oblique method. Dotted lines show how angles can be rounded in order to make the performance of the anastomosis more even. In performing the oblique anastomosis borders 1 and 2 are sewn together, border 3 is sewn to border 4 and to part of border 6, border 5 to the portion left unsewn of border 6, so that the two segments of the gut overlap each other and the line of anastomosis is oblique and the point where the two segments are anastomosed is almost double in circumference compared with the lumen of the intestine; this will prevent any possible dangerous stenosis.

that our point of view is correct, and if another proof was necessary, we could find it in the fact that, after the blood-vessels have been tied along the mesentery, the cut edges of the colon always bleed, and at times they bleed so profusely that single blood-vessels along the cut edges must be tied, and it is better to do so before performing the anastomosis. Therefore, the same considerations we have made above hold good when the anastomosis of the colon is to be performed; we may be allowed to state, however, that we believe that our oblique anastomosis represents the ideal method of anastomosing the colon, because it is rapid, safe, avoids loosening the two stumps, the anastomosis is made along the natural axis of the intestine, avoiding the formation of any pocketing and rendering stenosis of the line of union practically impossible.

Conclusions.—The intelligent reader will easily understand why we condemn the use of the thermocautery, of disinfection with any chemical

compound; *they do only damage the tissues without avoiding in the least the inevitable infection*; moreover, by-damaging the tissues they weaken the already low resistance of the same tissues and in this manner, instead of preventing or curing infection, they favor it.

As a conclusion we believe to be correct when we state that end-to-end intestinal anastomosis is not absolutely safe, because the tissues found in the mesenteric spaces (angles) are infected and their blood supply is practically nil, that in order to make it as safe as possible whatever can lessen the resistance of the tissues concerned in the anastomosis must be avoided, such as unnecessary traumata, blood-clots, great amount of suturing material, unnecessary infection, knots, tight sutures; the blood supply must be left in the best condition obtainable with a safe and perfect hæmostasis; all these desiderata are obtained with the technic we have recommended.

Indications for End-to-End Anastomosis of the Intestine.—When shall end-to-end intestinal anastomosis be employed in preference to side or oblique methods? The answer depends on the good judgment of the surgeon, who has to be guided by the following considerations, which seem to us very practical and reasonable: Given as basis for the considerations which have to guide the surgeon, that the same surgeon is really master of the technic of the surgery of the intestine, technically speaking there is no doubt that the end-to-end method is the most rapid of all methods by which anastomosis of the gut can be obtained. *It follows that the end-to-end method should always be resorted to in preference to any other method requiring more time, when, and only when, time is the most important factor that will help to save a patient's life.* By the expression that time would be the most important factor in saving a patient's life we mean to state that, given a patient whose probability of withstanding the resection of a part of the gut and consequent anastomosis depends on the rapidity by which the whole operation is performed, so that few minutes might have a great influence on the probabilities of his recovery, we think it more reasonable to perform an end-to-end anastomosis with any other method requiring more time. We base our reasoning on this consideration; supposing that the danger of losing the patient through leakage of intestinal contents into the abdominal cavity is 3 or 4 per cent. and the probabilities of losing the patient because the operation has required a longer time are 10 or 15 per cent., we give the patient the most favorable percentage, and the surgeon shall be guided by his own judgment in every particular case.

DEFORMITY OF THE SCAPULÆ ASSOCIATED WITH A CERVICAL RIB AND A SPINA BIFIDA

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THIS case is reported particularly because of the unusual congenital malformation of the scapulæ and shoulder girdles. There is associated an anomaly of the cervical and upper dorsal vertebræ. A survey of the literature does not show a similar case.

The patient, M. E. B., No. 10,822, a white female, age twenty-two years, entered the Barnes Hospital because of a left pes cavus. Her family history and past history are negative. She complains of pain about the ankle and great toe of her deformed foot, which pain has been present since birth. General physical examination is negative except for her shoulder girdles and the left foot. The patient's appearance is striking. She holds herself with shoulders thrown forward, with a marked prominence of the suprascapular musculature (Figs. 1 and 2). The supraclavicular fossæ are obliterated and there is only a very shallow suprasternal notch. The neck is thick and short and she is unable to bend her head backwards. The movements of the arms are normal but there is restriction in rotation of the scapulæ in that she cannot fully elevate her arms. The trapezii and levator scapulæ muscles are active, the former being hypertrophied. The rhomboid muscles give no response on Faradic or Galvanic stimulation. There is marked prominence of her seventh cervical vertebra, just below which there is a depression, marking the site of a spina bifida occulta. There is an impulse over this area on coughing. At the edge of the sternum, below the sternoclavicular joint, there is a nodule which appears to be in the cartilage of the first rib. The left foot has some shortening of the tendo Achillis, with marked shortening of the plantar fascia, causing a curvature of all toes of the foot. Urine negative. Blood Wassermann negative. Temperature and pulse normal.

X-ray plates show the scapulæ in an abnormal position (Figs. 3 and 4, No. 3); they are symmetrically placed near the vertebral column and are two ribs higher than in a normal individual. In this case the root of the spine of each scapula is at the level of the superior angle. The spine is overdeveloped, terminating in a very broad acromion. The coracoid appears normal. At the vertebral border of the scapulæ, reaching over to the defective vertebræ, is an extra plate which seems to be articulated with the scapulæ (Fig. 4,

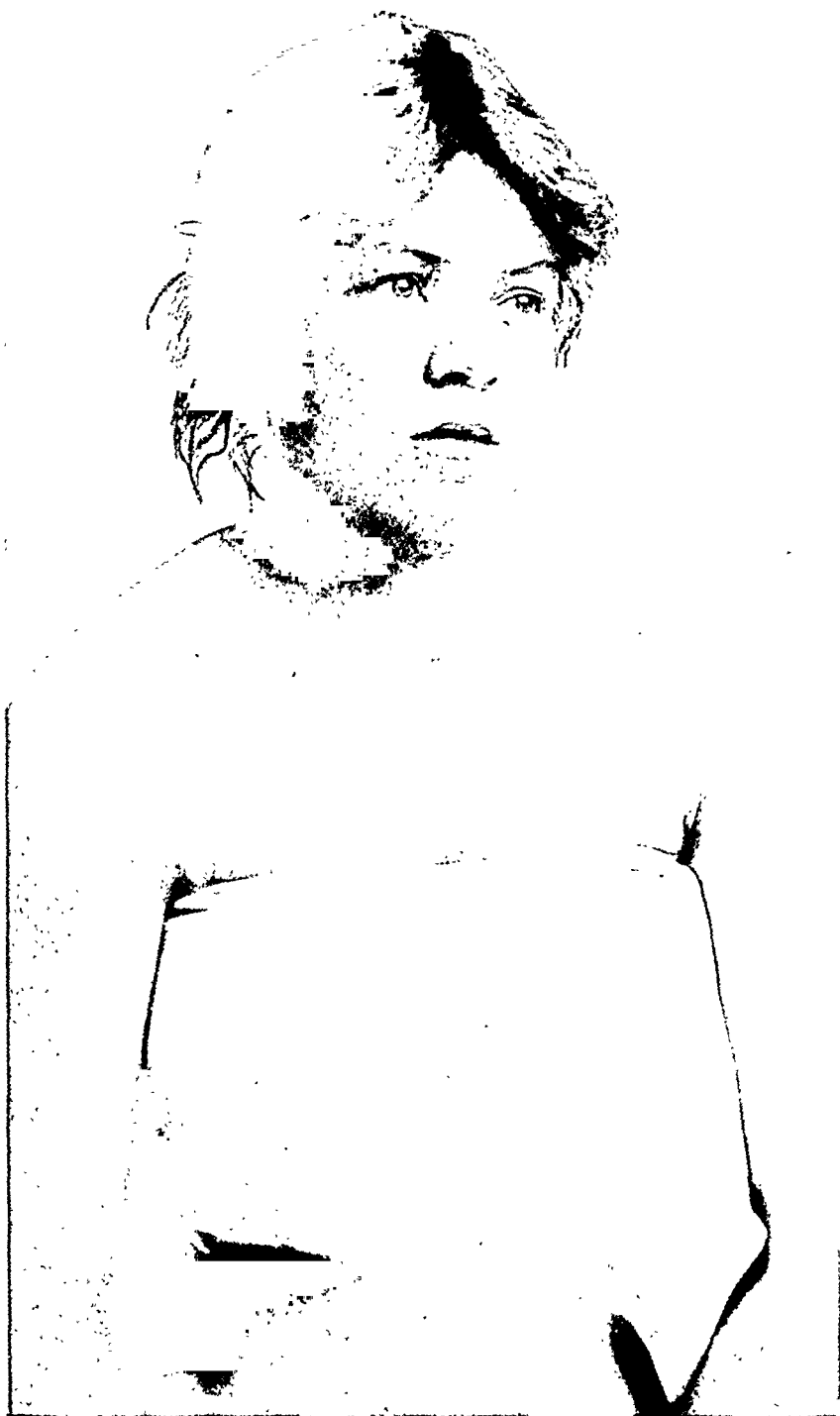


FIG. 1.—Position in which patient holds her shoulders.

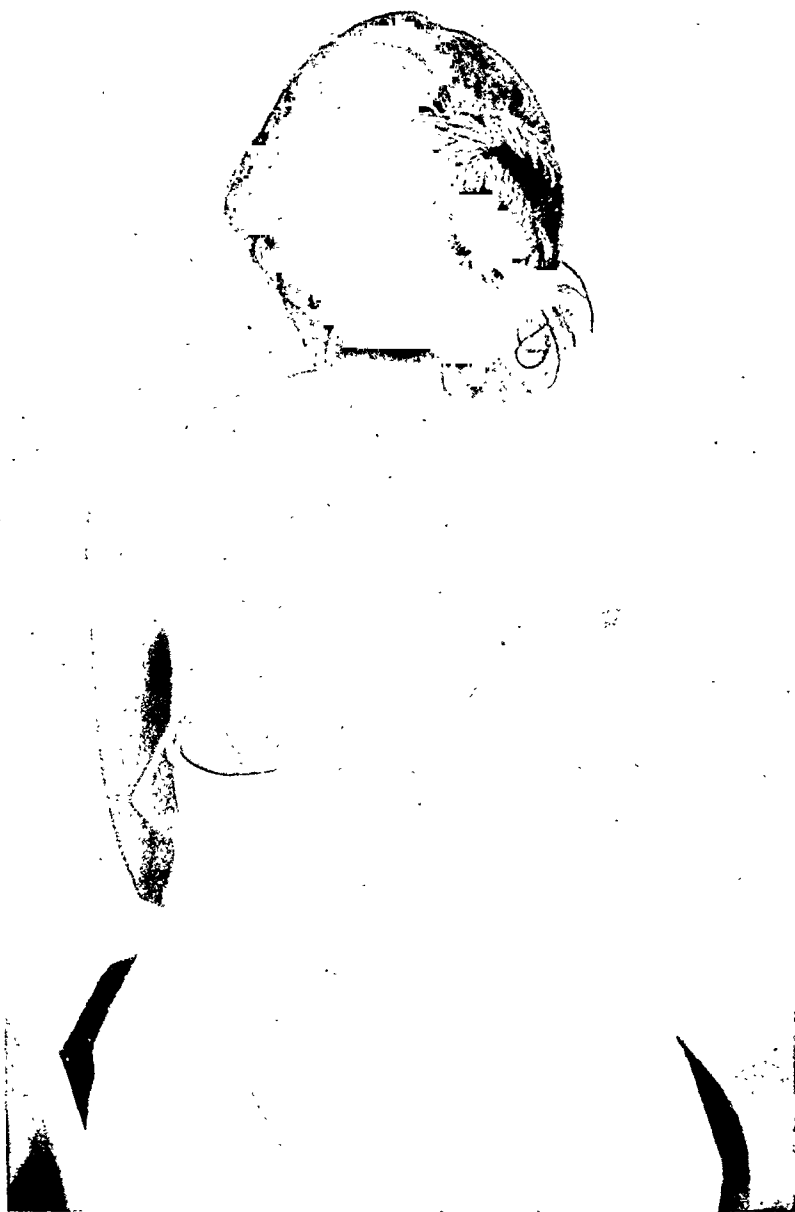


FIG. 2.—Position in which patient holds her shoulders.



FIG. 3.—Reproduction from stereoscopic X-ray plate showing anomalous bony plate, cervical rib and spina bifida. Plates taken in supine position.

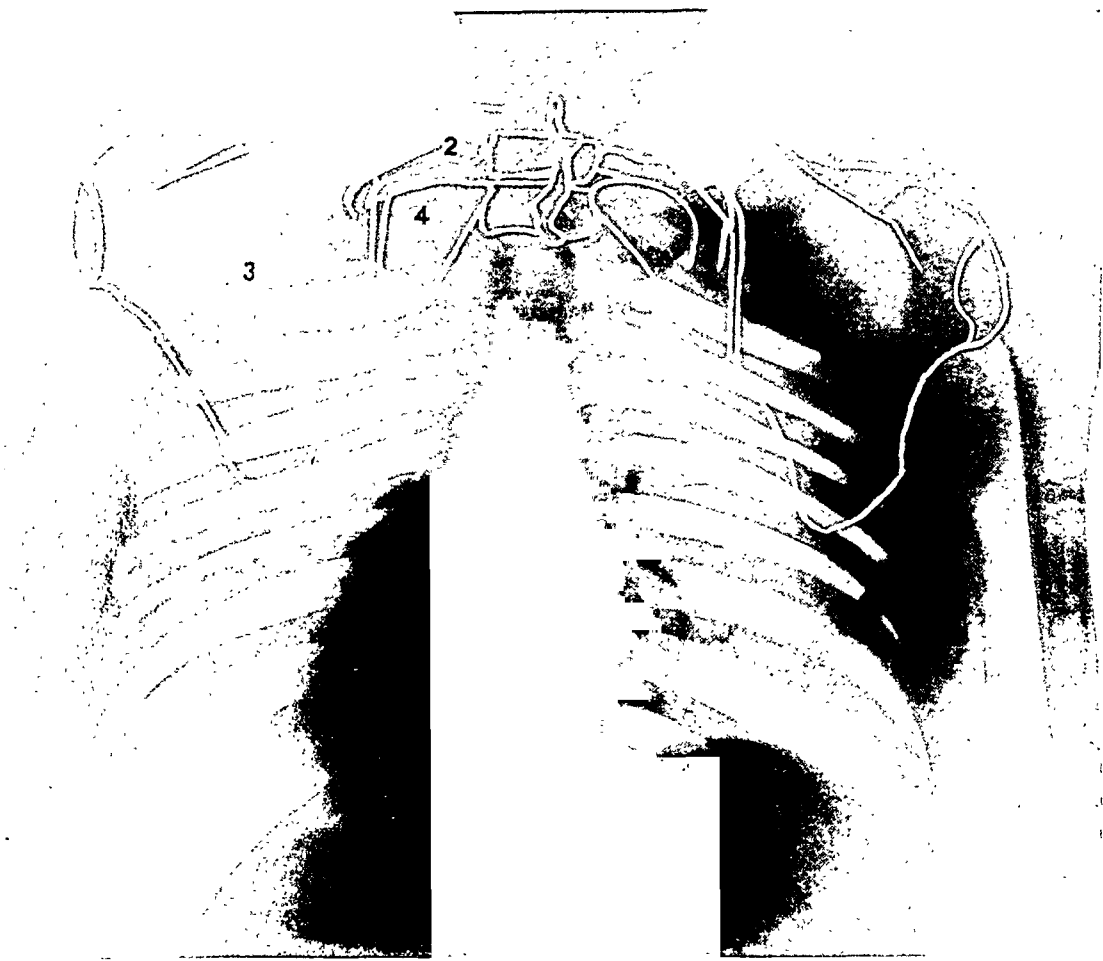


FIG. 4.—Same picture as Fig. 3, with the prominent features outlined. 1, spina bifida; 2, cervical rib; 3, scapula; 4, extra bony plate; 5, white spot—small nodule of bone.

No. 4). Extending upwards the apex of the plate reaches nearly to the first thoracic vertebræ. There is a hiatus in the seventh cervical, first, and second dorsal vertebræ (Fig. 4, No. 1). The clavicles are curved in their lateral third and, being broadly expanded there, present a more robust development than is typical in women. There is present a cervical rib (Fig. 4, No. 2) which curves around and seems to be attached at the edge of the sternum below the sternoclavicular joint, at the site of the nodule of bone (Fig. 4, No. 5) which was palpated there.

The abnormalities of position and form in the shoulder girdle may be attributed to the spina bifida and the triangular bony plate. The normal rhomboid musculature arises in part from the spinous process of the first thoracic vertebra, which vertebra in the present instance is absent. Apparently, the rhomboids are defective also; it may be that the triangular plate has replaced them. One important function of the rhomboids is support of the shoulder blades. In their absence, or if defective in development, the weight of the shoulders may be expected to fall somewhat on the other muscles which share with the rhomboids the maintenance of the normal position of the shoulder girdle, *i.e.*, the upper portion of the trapezii and the levator scapulæ. These two groups of muscles seem to have compensated well for the additional work thrown upon them by the absent or non-functioning rhomboids, and have drawn the shoulder girdles above their usual level. Contrary to the above interpretation, the elevation of the shoulder girdles may be regarded as a persistence of the cervical relation of the girdle as found in the embryo; the spina bifida as an arrest of the development of the vertebræ, with no influence on the position of the girdle, and the triangular plate as a "Reversion of Type."

The scapula is rarely absent and rarely malformed. The most common variation met with is a separated acromion process. Very much rarer are the cases in which the coracoid process is separated from the rest of the bone. There is a chief centre of development for the scapula proper and one for the coracoid, besides an indefinite number of accessory ones. The first centre appears about the eighth week at the neck and forms nearly the whole bone, including the spine, the root of the acromion, and the dorsal part of the root of the coracoid. The coracoid centre appears in the first year; it forms also the top of the glenoid cavity, and at fourteen or fifteen fuses with the first centre, beginning to unite on the ventral surface. At about fifteen years many nuclei appear in the acromion and fuse. A year later the mass so formed joins the body—sometimes this remains connected by fibro-cartilage. About seventeen or eighteen years nuclei appear; one in a strip along the posterior border, and one at the lower angle. Both are fused by twenty years of age, but the lower one is one of the last to fuse in the skeleton. The occurrence of a special primary centre for the coracoid process is of

morphological importance, in that the process is the representative of a distinct coracoid bone in the lower vertebræ.

The anomalous triangular plate of bone appears in the spot where a precocious development of the normally occurring epiphysis could account for it. It might be regarded as an ossification of an abnormal suprascapular cartilage. A suprascapular cartilage is not an uncommon part in the scapular in mammals, and is the rule in the lower vertebrates. However, a supraclavicular bone is developed in very few mammals beyond an epiphysis, or as an incomplete calcification of the suprascapular cartilage.

In medical literature there are reported numerous cases of extra ribs found in adults, both at the cervical and lumbar ends of the thoracic ribs, but more often at the latter site. Pillings reports a case of seventh cervical ribs that joined the sternum in the manner of true ribs. Persistent ribs are more frequently incomplete and fail to make a sternal attachment. The first pair of thoracic ribs are sometimes incomplete. The X-ray plates of this patient show an incomplete cervical rib extending about two-thirds of the way to the sternum. A small bony nodule previously described, lies at the site where the rib would apparently be attached were it complete. Possibly the rib is joined to the sternum by a ligamentous or cartilaginous band, with ossification of a small portion of the sternal end.

This case is of some interest phylogenetically. The elevation of the shoulder girdle recalls Gegenbaur's Gill Arch theory and the more modern Balfour's Fin Fold theory for the origin of the lower group of vertebræ. The cervical rib suggests the reptilian origin of mammals.

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TRANSACTIONS OF THE NEW YORK SURGICAL SOCIETY

Stated Meeting, held March 12, 1919

The President, DR. CHARLES H. PECK, in the Chair

OPEN OPERATION FOR FRACTURE OF PATELLA

DR. JOSEPH WIENER presented a patient, thirty-four years of age, who was admitted to Mt. Sinai Hospital, August 15, 1917. On day of admission he fell on left knee and sustained a fracture of the patella. The knee was swollen and the joint contained fluid. Flexion limited to 10° . Crepitus was felt and the patella was very tender. Several fragments could be felt widely separated.

Operation five days after admission. Five inch horseshoe flap over patella. Clots removed from joint and two large fragments of bone united with chromic gut after drilling holes through the fragments. Capsule sutured with chromic gut. Wound healed by primary union. Functional result very good.

DR. CHARLES L. GIBSON asked whether he understood correctly that Doctor Wiener operated on the fractured patella on the fifth day and regarded that as early? He has nearly always operated for fractures of the patella on the fifth day and has regarded that as the time of election rather than a later date, and he may say that his results have been uniformly good.

DR. JAMES M. HITZROT said his experience agreed with that of Dr. Gibson. He operated upon the fifth day and had had no infections. The essential feature was the proper preparation of the skin for operation in his opinion. Some years ago the question of immediate operation *versus* later operation in fractured patella had been discussed. The features, which in his experience contraindicated immediate operation, were the exudation into the joint and the infiltration of the torn tissues subsequent to the operation, which materially interfered with the approximation of the bone fragments and the torn ligaments; and probably caused the approximating sutures to cut through.

Two parallel series of cases of ten each were then operated upon—ten immediately and ten at the five day interval. Exactly similar operations were done and there was no other contributing cause in the result. In the ten cases operated upon immediately, the functional result was not as good and extension was not as complete nor as strong as that obtained in the cases at the five day interval. The delay also allowed for the hemorrhage to stop and for the proper skin preparation and was more preferable than the immediate operation.

DR. LUCIUS W. HOTCHKISS said he had one case of fractured patella by direct violence last summer caused by the patient's falling from a horse. He operated a little earlier than usual in this case, but as a rule he did not operate early in these cases.

DR. JOHN DOUGLAS said that some ten or fifteen years ago Dr. Carlton Flint wrote a paper in which he analyzed a large number of cases of fracture of the patella. He considered the figures in cases operated on early and those operated on after a period of time, and he showed that the results of the later operations, that is, a week or ten days after the fracture occurs, did better than the cases operated on earlier. He gave as a reason, that the amount of exudate causes a separation of the fragments and also that suppuration was more apt to take place after the suture of bruised tissue which has lost its resistance. He, Doctor Douglas, always allowed his cases to go a week before operating. He thought we gained nothing by an early operation inasmuch as the resistance of the tissues is better at a later period, and firm union of the bone occurs just as soon as if an early operation were done.

DR. PENN G. SKILLERN, JR. (by invitation), stated that the practice in dealing with fresh fractures of patella in Philadelphia is quite the same as that outlined by those who discussed Doctor Wiener's case. He, personally, followed the teachings of the late Dr. John B. Murphy, who stressed the importance of giving the tissues time to coffer-dam themselves against infection from without by erecting a barrier of leucocytes and closing the open lymphatics: for this usually from five to eight days were allowed.

Personally, Doctor Skillern agreed with Doctor Hitzrot; for as a practical proposition no time in the process of repair is lost by waiting for coffer-damming to take place, especially since in a fracture lime-salts are rarely deposited before the fourteenth day.

DR. CHARLES H. PECK remarked that it seemed a pretty well accepted principle to-day to delay the operation for a time in these cases of fractured patella.

EXCISION OF TUMOR OF THE CAROTID BODY

DR. JOSEPH WIENER presented a patient, thirty-seven years old, who was admitted to Mt. Sinai Hospital, December 9, 1918. Eight years before admission she first noticed a swelling on the left side of the neck. This has slowly increased in size without causing any pain. On examination he found a swelling in the upper angle of the anterior triangle of the neck about the size of a small hen's egg. It was elastic to the touch and rather freely movable under the skin. There was no tenderness. The thyroid gland was not enlarged.

Operation under gas and ether. Incision started behind the angle of the jaw downward and forward. The tumor was very vascular and fixed to the deeper structures. Bleeding was very profuse from numerous enlarged veins and from many smaller arteries. Owing to the severe hemor-

rhage the incision was quickly extended downward to the clavicle. The internal jugular vein was enormous, measuring an inch in diameter; the common carotid was also very large. Both these vessels were doubly ligated with silk without being cut. As the bleeding from the tumor did not cease the patient was given an intravenous injection of saline solution. Numerous large vessels above the tumor were then clamped and ligated. This finally checked all bleeding. The tumor with the bifurcation of the common carotid incorporated in it was then dissected free and removed by cutting across common carotid and internal jugular. The wound was closed with drainage.

The specimen consisted of a two-lobe tumor, firm and hard, about two inches in diameter, with the common carotid and its bifurcation and the concurrent veins incorporated in it. Following operation there was some left facial paresis with marked weakness of right arm and leg. For several days morphine had to be given to control coughing spells. On December 17 the laryngologist verified paralysis of left vocal cord. All symptoms of paresis and paralysis soon disappeared. Coolidge treatment is being given regularly and there is no sign of any relapse.

Pathologic diagnosis was perithelioma.

DR. JOHN DOUGLAS stated that some years ago he had a patient with perithelioma of the carotid body which he reported and, during the discussion which followed, someone remarked that most of these tumors recurred. He operated on this patient eight or nine years ago and was able to follow the patient for six years, and up to that time there was no recurrence. He believes the tumor starts in the bifurcation of the carotid and spreads around the vessel, and the reason the carotid appears to go through the tumor is that the tumor grows in such a way as to surround the blood-vessel.

DR. WILLIAM B. COLEY said he had a tumor of the carotid body in which the growth was located at the bifurcation. He operated on this patient at the New York Hospital. The tumor was closely adherent to the blood-vessel, making the operation very difficult. The tumor was removed, however, and the patient remained well for a year or two, when he lost track of him, so he could not say whether or not he was still alive.

DR. WINFIELD S. SCHLEY said he had a case about three years ago with a tumor at the bifurcation of the carotid artery in which he ligated all three branches and removed the tumor with the vessels. He saw this patient the other day, about three years after the operation, and there were no signs of recurrence. He reported this case before the Surgical Society and it made the seventy-fourth or seventy-fifth case in the literature. In a review of these cases he found that the prognosis was fairly good but it was vastly better where the tumor and vessels were removed together. In the cases in which enucleation was practised without vessel excision there were recurrences, as he remembered, in fully 50 to 60 per cent. of the cases.

DOCTOR PECK asked if, in this series of cases mentioned by Doctor Schley, there were many cerebral symptoms following the ligation while the collateral circulation was being established.

DOCTOR SCHLEY said he did not think there were.

DOCTOR WIENER, in closing, said he thought the prognosis would be improved by the Coolidge treatment. He now had a Coolidge apparatus in his office and he was using it after operation in all superficial growths that are malignant or suspicious of malignancy. He thinks this treatment is powerful in preventing the recurrence of carcinoma.

He had one patient who, after an operation for carcinoma of the breast, had a recurrence in the sternum, the tumor being as large as a hen's egg. It disappeared entirely under the Coolidge treatment and three months later X-rays taken with the patient in three different positions showed no trace of the tumor. Doctor Erdmann and Doctor Gibson saw this patient at the time she had the tumor in the sternum. She subsequently succumbed, however, to a cerebral metastasis. He used the Coolidge treatment a great deal and he expected to continue to use it in more and more cases.

COMPLETE DISLOCATION OF ANKLE WITHOUT FRACTURE OF LEG BONE

DR. SETH M. MILLIKEN presented this case because before seeing it he had believed that such a condition was impossible and he had in his library no record of a case presenting so much derangement of the mortise of the ankle without an associated fracture.

On May 21, 1918, a large, very heavy man, about thirty-eight years old, with marked flat feet, a chauffeur by occupation, was standing in an elevator when its cable parted and the elevator dropped one and a half floors, 15-20 feet, and stopped with sideways tilt. The jar twisted his right ankle so that he was unable to walk. He was helped to Roosevelt Hospital, where Doctor Milliken saw him immediately. Examination showed the foot apparently rotated to a right angle outward. The lower extremity of the tibia was projecting under the tense skin with a very slight wound over its tip and felt as if the entire lower surface was completely displaced from the astragalus. The fibula was bent outward and its outer surface could be easily palpated its entire length. He examined for a fracture but was unable to find one, so had an X-ray taken. To his surprise, the plate showed no fracture but showed an outward dislocation of the astragalus from the tibia. The astragalus was jammed up between the outer surface of the tibia and the unfractured fibula, wedging them apart. Reduction of the dislocation was very easily accomplished by traction and slight rotation and the astragalus jumped back into place. Subsequent X-rays showed the ankle restored to its habitual position. A plaster cast was applied from the toes to the knee. This was removed on June 1 and the angle re-supported in firm Gibney's strapping. No



FIG. 1.—Before reduction. Plate of entire leg showed no fracture.



FIG. 2.—Before reduction. Shows upward displacement between leg bones.



FIG. 3.—After reduction. Moulded splints applied.



FIG. 4.—After reduction. Moulded plaster of Paris splints applied.

FIBROMA OF THE ABDOMINAL MUSCLES

weight-bearing was allowed but active motion was encouraged until June 17, after which walking was begun. On July 3, the patient could walk a short distance without discomfort and had almost as much motion in the injured as in the uninjured ankle. At the present time he has pain, especially when weight comes on front of foot.

DR. JAMES M. HITZROT said the case was undoubtedly unique. Dupuytren described a group of fractures in which the inferior tibiofibular ligament was torn, the fibula fractured in which the astragalus ascended between the bones, but that he knew of no similar case to that presented by Doctor Milliken.

DR. NATHAN W. GREEN said that he had had a case somewhat like Doctor Milliken's, in which Doctor Hotchkiss was called in consultation. The patient had been sliding down hill with her little daughter. She caught her foot in an iron fence and dislocated the astragalus completely inward, compounding it completely. When she arrived at the house the astragalus was lying out in the bedclothes and there was apparently no fracture of the leg bones. Close inspection of the X-ray showed a fracture of the tibia about eight inches above the joint, but there was no deformity. The astragalus was completely dislocated and it could not be replaced and so he snipped off a small strip of ligament and removed it.

FIBROMA OF THE INTERNAL OBLIQUE AND TRANSVERSALIS MUSCLE

DR. NATHAN W. GREEN presented a patient with the above condition. He accompanied the presentation with a brief paper on the condition, for which see page 600.

DR. JOSEPH WIENER said he had had two cases very similar to the one Doctor Green has presented, both in women. One had a small growth in the right lower part of the abdomen, which could be enucleated, while the second was in the right upper quadrant and was not encapsulated but was infiltrating the muscle tissue. As no pathologist was present at the time of the operation to make an immediate examination and he feared malignancy, he made a wide incision. He then found it was very difficult to close the incision. He devised a large wire filigree and fortunately this wire filigree stayed in place. He later found that the growth was not a sarcoma, but the character of the tumor, resembling a fibromyoma and being about three-fourths encapsulated and one-fourth perforating through into the muscle, deceived him into thinking that he was dealing with a malignant tumor.

DR. CHARLES H. PECK said he had a case of fibromyoma of the internal oblique and transversalis on the left side very similar to this one presented by Doctor Green. It was not well encapsulated, but merged into the internal oblique and transversalis. There was no vascular pedicle. He made a wide excision in removing the tumor, leaving a large defect to be closed. Closure was effected with some difficulty but successfully; no hernia resulted. He followed the patient for seven years and she was all right up to that time. He had a second case that hardly belongs in

the same class, although it had similar features. It was a fibrous tumor of the abdominal wall studded with calcareous nodules. It proved to be malignant, as the patient died subsequently of a metastasis.

DOCTOR GREEN, in closing, said he had nothing to add except that he had had another case with a tumor similarly situated in the muscles, but he could not recall whether in the internal oblique and transversalis or not. He remembered that it could not be shelled out. In this case presented this evening the tumor did not involve the external oblique in any way, so, although he made a wide excision and had a very large defect, the rectus and the external oblique were still intact. This enabled him to make a good closure.

INTRA-PERITONEAL ABSCESS DUE TO FISHBONE PERFORATION OF INTESTINE

DR. WINFIELD S. SCHLEY presented a small boy, nine years of age, who was admitted to the hospital a year ago. Several weeks before his admission he complained of indefinite abdominal pain. Three days before the pain recurred with considerable severity and localized upon the left side near the umbilicus.

The family history was negative. The boy has been rather careless as regards his bowels and had been a rapid eater.

At the time of admission he had an acute intra-abdominal condition with rigidity, etc. There was a mass on the left side extending below the umbilicus and under the left rectus muscle. On opening the abdomen the omentum was found to be wrapped in a ball-like mass completely around an abscess, and was in contact with the descending colon and the small intestine behind to both of which it was adherent. On opening the mass it was found that quite a large (codfish) bone had perforated either from the large or small intestine; it was impossible to say which. The discomfort which the boy experienced prior to the acute onset was probably at the beginning of the perforation of the gut. He excised the mass of omentum and placed in a small rubber drain. No other abnormality was present. The boy made a good recovery.

In the specimen presented the protective action of the omentum in such accidents is well shown.

INOPERABLE MELANOTIC SARCOMA OF THE NECK; ENTIRE DISAPPEARANCE UNDER ACCIDENTAL STREPTOCOCCUS INFECTION; PATIENT WELL MORE THAN THREE YEARS

DR. WM. B. COLEY presented a little girl, aged seven and one-half years, who was referred to him for observation by Dr. Robert C. Bryan of Richmond, Va., with the following history:

On June 20, 1915, when Doctor Bryan first saw the patient, there was enlargement of the neck with involvement of the cervical glands. This had been noticed for about four months. The swelling first began in the

left jaw and two weeks later was also noticed in the right side of the neck. The child had always been in the best of health up to this time. An examination was made by Dr. F. W. Mercer, who pronounced the throat, nose and ears normal. A physical examination showed the submaxillary, cervical and supraclavicular glands symmetrically enlarged and matted together, the enlargement being more pronounced on the left side. A probable diagnosis of Hodgkin's disease was made. Blood examination was negative.

On July 7, 1915, a small incision was made over the submaxillary gland at the angle of the left jaw and two small glands were removed for microscopical examination, which was made by Dr. S. B. Moon of the Medical College of Virginia, who reported:

The sections are composed mainly of actively proliferating embryonal connective-tissue cells, mainly spherical, but varying widely in shape and size. An occasional giant cell is seen. The vessel walls are thin or lacking, and when present intimately associated with the tumor cells. In some areas pigment granules, apparently melanin, are abundant in the cell protoplasm. Fibro-elastic tissue, fat and striated muscle are definitely infiltrated by the tumor cells in their advance. Diagnosis: Melanosarcoma.

The case was quite inoperable and a hopeless prognosis was given the parents. The tumor slowly increased in size until December 25, 1915, at which time there was also beginning emaciation. On December 26, the neck began to enlarge very rapidly, became red and swollen, temperature rose to 106° and pulse 180. There was marked cyanosis, great dyspnoea, and evidence of severe infection in the tumor. On December 27 the child became unconscious. On the following day under primary anæsthesia a median incision was made under the jaw, a large amount of sero pus being evacuated (2 to 3 ounces). A specimen was examined by Doctor Moon, who reported: "Pus from neck is streptococcic with various saprophytes."

The infection slowly subsided but the wound remained open for several weeks. The tumors of the neck gradually decreased in size and in a short time entirely disappeared. The child has remained in good health up to the present time, three and one-quarter years later. Doctor Coley added that a microscopical examination of the specimen removed was also made by Doctor Ewing, who confirmed the diagnosis of melanoma.

Doctor Coley states that in the 68 collected cases of malignant tumors in which an attack of intercurrent erysipelas was immediately followed by great improvement in the local and general condition of the patient, one of these cases, in which entire disappearance of the tumor took place, was a melanotic sarcoma. Doctor Coley stated that the melanotic sarcomas or melanomas had been the least favorably influenced by the mixed toxins of erysipelas and bacillus prodigiosus of all types of malignant tumors. Still, there had been a few cases in which the tumors had entirely disappeared, and three or four patients that have apparently remained perfectly well. Doctor Coley stated that he personally had had

few encouraging results, but that he had just learned of a four-times recurrent melanotic sarcoma of the neck in which the toxins were used in December, 1914, by the patient's husband, a physician, who recently wrote that his wife was in the best of health with no evidence whatever of a recurrence. As to cases of melanotic sarcoma, in the early case that was associated with pressure symptoms the tumor entirely disappeared after the infection. In another case coming under his observation a complete disappearance of the tumor followed an attack of erysipelas. Doctor Lilienthal and Doctor Greenwood have reported similar cases. Doctor Greenwood's case occurred in a boy seven years of age and the growth entirely disappeared after an attack of erysipelas. His experience with melanotic sarcomas is that he has not been very successful in treating them with radium, with one exception. This patient was the wife of a physician who had had four operations and had had a piece of the growth removed for examination. In December, 1914, he began treating her with radium and the X-ray, and she began to pick up and continued to improve. He saw her only a few days ago when she was still perfectly well. As a rule, radium and the X-ray have less effect on these tumors than on tumors of any other variety. As for the tibia case he could not say it was cured, but an amputation had been avoided and the periosteal growth inhibited. There were very few cases of this kind that have gotten well even after high amputation and where the growth had been a primary one.

PERIOSTEAL SPINDLE-CELLED SARCOMA OF THE TIBIA, WITH METASTASES IN THE INGUINAL AND FEMORAL GLANDS; DISAPPEARANCE UNDER TOXIN AND RADIUM TREATMENT; WELL AT PRESENT NEARLY TWO YEARS

DR. WILLIAM B. COLEY presented a man, thirty-nine years of age, who was referred to him on April 27, 1917, by Dr. John H. Gibbon of Philadelphia. Family history negative. Personal history: The patient's general health had been very good, and he had practically never been ill. Ten years before, he was struck by an automobile and suffered a compound fracture of the right leg, four inches above the ankle. There had been no injury to the left leg as far as known. Four weeks before he was referred to Doctor Coley, the patient noticed a swelling about two inches above the left ankle, extending upwards and involving the inner and anterior portion of the leg for a distance of six inches. It was at first believed to be a periosteitis of inflammatory origin. In the latter part of April Doctor Gibbon was called in consultation, and pronounced it probably sarcoma. This opinion was strengthened by an X-ray examination.

Physical examination at the time of Doctor Coley's first observation (April 27, 1917) showed a man in robust health. Examination of the left leg revealed a marked swelling occupying the lower third, apparently originating in the periosteum and extending nearly around the leg. It began about an inch above the internal malleolus and extended upwards

five inches anteriorly, and $4\frac{1}{2}$ inches on the outer side of the fibula. There was marked œdema of the whole lower third of the leg extending to the ankle. The swelling, which was most prominent over the inner and anterior part, was soft, almost semi-fluctuating, and markedly tender on deep pressure; the skin was slightly discolored. T. = $99:5^{\circ}$.

Doctor Coley believed it probably sarcoma but thought it most important to settle definitely the diagnosis, and on April 27 made an exploratory operation. A portion removed was examined microscopically by Doctor Ewing, who reported: "Section shows a tumor composed of small spindle cells consisting chiefly of nuclei. They are very numerous, with no visible stroma. The cell masses are very compact. The tumor is quite malignant in structure."

The patient was immediately put upon the mixed toxins of erysipelas and bacillus prodigiosus, which were continued 4 or 5 times a week in doses sufficient to produce a temperature of $102-104^{\circ}$.

Measurements (April 30, 1917).—1 inch above the internal malleolus, $9\frac{5}{8}$ inches; 4 inches above the internal malleolus, $10\frac{5}{8}$ inches; 6 inches above the internal malleolus, $10\frac{3}{4}$ inches. The tumor itself, anteriorly, $5\frac{1}{2} \times 5$ inches.

May 5, 1917.—4 inches above internal malleolus, $10\frac{3}{8}$ inches; 6 inches above internal malleolus, $10\frac{3}{8}$ inches. The tumor itself, $4\frac{1}{2} \times 4 \times 3\frac{1}{2}$ inches.

May 11, 1917.—4 inches above the internal malleolus, $9\frac{3}{4}$ inches; 6 inches above the internal malleolus, $9\frac{3}{4}$ inches. The tumor itself, $4 \times 3 \times 2$ inches.

On May 1, 1917, the patient was treated with radium emanations 12 x 85 mc. (1020 mc.) through 2 mm. lead filter, 6 cm. distance, applied to the anterior surface of the leg for twelve hours.

On May 8, he received the following radium emanations: 660 mc., 2 mm. lead filter, 10 cm. distance, applied to the inner aspect of the leg for twelve hours, and on May 23, the same amount of radium emanations, 2 mm. lead filter, 6 cm. distance, applied to the external aspect of the leg for twelve hours.

X-ray examination by Doctor Quick, May 14, 1917, showed: "In the lower half of the left tibia there is an area of bone 13 cm. in length and embracing for the most part the anterior and inner side in which the bone, both cortex and periosteum, is involved by a destructive and rarefying process.

"Diagnosis: Periosteal sarcoma."

Measurements (May 21, 1917).—Circumference of leg across centre of scar, $9\frac{1}{4}$ inches.

May 25, 1917.—Circumference of leg across centre of scar, $9\frac{1}{4}$ inches; upper end of scar, $9\frac{9}{16}$ inches; lower end of scar, $9\frac{9}{16}$ inches; at malleoli, $9\frac{3}{4}$ inches.

On May 26, 1917, the patient returned to his home, where the toxins were continued three times a week by Dr. R. G. Gamble, his family physician, and on June 19 he was again admitted to the Memorial Hos-

pital for further radium treatment, at which time he received 1200 mc. emanations, through 2 mm. lead filter, 10 cm. distance, applied to the internal surface of the leg for eight and one-half hours. The toxins were then continued at home during June and July, but in view of the fact that all evidence of the disease had disappeared and he was in such fine general condition it was thought safe to discontinue the treatment for four weeks during the extreme heat in August and September.

X-ray examination by Doctor Quick, July 2, 1917, showed: "As compared with plates of a month ago there is distinct improvement in that the bony outline is less ragged and tending to a sclerosis."

The patient returned to Doctor Coley for observation on September 15, 1917, stating that he had recently discovered swellings in the left groin, which were increasing in size. A physical examination showed the leg to be apparently normal. The left groin was occupied by several large glands involving both the inguinal and iliac regions, the largest of which was about the size of a big hickory nut. Doctor Coley removed one of these under general anæsthetic and forwarded it to Doctor Ewing for microscopical examination, who reported: "Actively growing sarcoma. Cells large polyhedral. No pigment. Nature of origin uncertain."

Radium Treatments (October 1, 1917).—Radium emanation pack 600 mc. for seven hours, 2 mm. lead filter, applied at a distance of 10 cm. to the left inguinal and femoral regions.

October 2, 1917.—Radium pack, 480 mc., 2 mm. lead filter for twenty-nine hours, at a distance of 10 cm. to the same region, making a total of 18,120 mc. hours.

November 8, 1917.—Radium pack, 1400 mc. (2 mm. lead, 0.5 mm. German silver) applied at a distance of 8 cm. over the left inguinal region for six and three-quarter hours.

November 9, 1917.—Radium pack, 1420 mc. (2 mm. lead, 0.5 mm. German silver) applied at a distance of 8 to 10 cm. over the left inguinal region for six hours.

December 7, 1917.—Radium pack, 1800 mc. for six and two-third hours (2 mm. lead, 0.5 German silver) applied over the left inguinal region at a distance of 8 to 9 cm.

The toxins have been continued up to the present time with occasional intervals of rest. The doses have been comparatively small, not sufficient to interfere with his regular occupation, and his general health has remained perfect throughout the entire time.

A recent physical and X-ray examination showed apparently no trouble remaining in the tibia, and no evidence of metastases in any other part of the body.

This case, Doctor Coley believed, illustrated the advantage of combining the local effect of radium with the systemic effect of the toxins; it also showed the importance of keeping up the toxin treatment in certain cases for a considerable period. Doctor Coley added that it was too

REPAIR OF VENTRAL HERNIA

early yet to say that the patient was permanently cured, but nearly two years had elapsed since the disappearance of the primary tumor, and one and one-half years since the secondary one.

REPAIR OF VENTRAL HERNIA

DR. CHARLES L. GIBSON presented a patient who was shown here three years ago and was presented again now to demonstrate the permanency of cure. At that time he also showed a patient whose operation now dated back five years. He was unable to show her to-night as she was now in California, but a recent report from her stated that she was absolutely well and was able to take vigorous physical exercise.

The operation was applicable to any form of ventral or umbilical hernia and particularly in the repair of large post-operative incisional herniæ. The essential step of the operation was the utilization of pedunculated flaps of the anterior sheath of the rectus muscle, these flaps being cut exactly as are Langenbeck's flaps in the repair of cleft palate. The length and width of these flaps varied according to circumstances, but the result must always be the possible approximation of the refreshed free edges as in ordinary suture of abdominal wounds. The rest of the operation—closure of peritoneum, dissection of recti muscles, etc.—was the same as in ordinary laparotomies. It would seem at first sight that a weak place was left in the abdominal wall produced by the gap in the fascia of the rectus. Ordinarily, the rectus muscle underlies this and there was no trouble, but even in cases with such a deficiency, the results had been uniformly good.

He had hoped to show a patient who illustrated the extreme possibilities of this method but she had not come. However, he said if the members present would permit him he would say a word about her case. She was an Italian woman operated on in 1902 in the New York Hospital. After this she had had an epigastric hernia, repaired in August, 1912. In September, 1913, she had returned with a ventral hernia which had been repaired, using silver filigree $4\frac{1}{2}$ inches by $3\frac{1}{2}$ inches. In October, 1918, the wire broke through, causing pain. It was found that there was bulging at the site of the previous operation and the wire filigree was broken and a discharging sinus was present. The wire filigree could not be pulled out. He decided to make this a test case. Under local anæsthesia he removed the wire filigree and he then had a large infected wound which he simply closed with drainage. Later the operation as described was done. There was some difficulty with the infection but he finally succeeded in getting union. It was now three months since the operation and he had tried to bring her here to show that she had a perfectly good abdominal wall at this time. The last operation was performed on November 23, 1918. He believed this operation is suitable for the repair of any hernia unless it is an umbilical hernia, and even for an umbilical hernia he believed it was surer than the overlapping operation.

NEW YORK SURGICAL SOCIETY

DR. JAMES M. HITZROT said that Doctor Gibson did not give himself sufficient credit for the difficulties encountered in that case. The woman had been operated upon twice for the hernia. The first operation (Doctor Hitzrot) was the ordinary type with dissection of the edges and approximation of the edges under tension. She developed bronchitis after the operation and the hernia recurred. At the second operation there was a large gap and to fill this a six-inch prepared silver wire filigree mat was used to fill the defect. This cured the hernia and had not caused her any trouble until three months ago when a sinus formed and began to discharge.

This was undoubtedly due to the broken wires in the filigree as the sinus only formed over the sharp edges of the broken wires.

The difficulty after the removal of the filigree was the closure of an eight-inch gap which the operation which Doctor Gibson has devised very ably met. The operation has very successfully replaced the use of foreign material to close these large ventral herniæ.

DR. WILLIAM B. COLEY stated that he believed Doctor Gibson's operation to be a distinct advance in dealing with this kind of a ventral hernia. Personally, he was opposed from the first to the use of filigree wire in any type of operation, because of the end-results which he had observed in cases in which it had been used. In some cases the wire had broken up into small pieces which had found their way into different parts of the abdomen, some entering the bladder and causing vesicular calculi. Doctor Coley referred to a monograph written by a German surgeon two years ago, on obscure tumors due to filigree and other non-absorbable suture material used at the time of operation for the radical cure of hernia. He added that any type of hernia that could not be cured without the use of silver wire or filigree had best be left without operation.

DR. CHARLES H. PECK said the question of tension was very important. In the overlapping operation one estimated the degree of tension and the strength of the edges by the sense of touch. It is important to dissect away weak tissues until we get a firm edge. A considerable degree of tension was unavoidable in the overlapping operation for large hernia, but if sutures are sufficient in number and carefully placed, tension did not prevent good healing and firm repair.

He used absorbable sutures almost exclusively: heavy chromicized catgut; one row of mattress sutures and two rows of supporting sutures. He thought the overlapping operation more successful than the edge-to-edge operation or the filigree. This method of Doctor Gibson's was a very valuable suggestion and might be of great assistance in many of these large ventral hernias.

INGUINAL HERNIA

DR. FRANZ TOREK read a paper with the above title.

DR. WILLIAM B. COLEY stated that he thought Doctor Torek's paper should convince anyone that the idea so commonly held that the operation for hernia was a simple one, was fallacious. There are many fine points in the technic that play an important part in the success of the operation. In regard to Doctor Torek's particular technic, Doctor Coley thought he had given undue emphasis to the importance of separating the vas from the vessels of the cord in bringing them out through separate openings. Doctor Coley did not believe that this step played an important rôle nor did he agree with Doctor Torek about the hernial sac coming out between the vessels and the vas. Doctor Coley believed that anyone who has operated upon a large number of cases for the radical cure of hernia, especially in children, learns that the sac lies directly on top of the vessels and the vas which are spread out in a fan-like manner over the posterior wall of the sac. He has never seen a case in which the sac came out between the vessels and the vas, as described by Doctor Torek. Doctor Coley added that he always tied off the peritoneum high up beyond the neck of the sac without separating the vas from the cord, which method has given ideal results.

With regard to direct hernia, Doctor Coley had always transplanted the fascia of the rectus muscle or the rectus itself until very recently, when a new method occurred to him, and which he has used in three or four cases. Where one has a direct hernial sac he removes the same flush with the abdominal cavity. The transversalis fascia then remains wide open and this opening he treats precisely as anyone treats an umbilical hernia, according to the Mayo method of overlapping, in which the upper layer is brought underneath the lower, and then sutured to Poupart's ligament, after which the regular steps of the Bassini operation are carried out.

Doctor Coley wished to add one word about the sutures. He stated he was glad to know that Doctor Torek had abandoned silver wire with the exception of the two lower stitches of the deep layer, and he believed that in the near future Doctor Torek would abandon it altogether. He stated that, in his opinion, the absorbable suture was the only one that had any place in the hernial operation. Any suture that remains unabsorbed for a period of more than three or four weeks loses its tension and then remains as a foreign body. Doctor Coley has already pointed out the disadvantages of non-absorbable sutures so frequently that he did not think it necessary to repeat them on this occasion. He stated if one could see the after-results from the use of non-absorbable sutures, in the Out-Patient Department of the Hospital for Ruptured and Crippled, one would soon abandon their use.

DR. SETH M. MILLIKEN said he agreed with Doctor Torek's modification for the closure of the external ring. He had operated on a great many hernias referred by army and navy examining boards where there was no true sac, where there was a sac only on traction upon the cord, and in

these cases we find the vas behind the vessels and so close to them that it is impossible to tell from which side the sac comes.

DR. J. P. HOGUET asked Doctor Torek what per cent. of his cases were adults and what per cent. children, and whether he had seen most of these cases within the last few months.

As to direct hernia, it did not seem to him that this operation, whereby we make two weak points, is very rational. Naturally we must consider the question of recurrence and it is logical to believe that there will be more recurrences where there are two points with direct outside paths of emergence. The point at the internal ring external to the deep epigastric vessels, and also the point behind the external ring.

Doctor Torek does not fortify the external ring by allowing the vas to come out just external to the pubic spine, and that makes a weak spot, through which a direct recurrence would be very apt to come.

DR. LUCIUS W. HOTCHKISS said it was agreed that there was a great difference between hernias in adults and children. In children very often it was merely a question of the high ligation of the sac. In adults with a tendency to direct hernia one will find often a second sac to the inner side of the deep epigastric vessels. This is so common that overlooking it is one of the chief causes of so-called recurrence.

Another point to which he called attention was that there is sometimes a little piece of fat present that we take for a sac. He once ligated what appeared to be such a piece of fat and found that it was a diverticulum of the bladder.

This whole subject of hernia has been gone over very carefully in the camps and he thought that we must all revise our ideas and agree as to the necessity of doing a very careful operation. He thought Doctor Torek's points had been well taken and he had shown the need of great care in all operations for hernia.

DR. NATHAN W. GREEN said nineteen years ago, when he was an interne at St. Luke's Hospital, it was his good fortune to work with two attending surgeons, one of whom used non-absorbable sutures, and the other used absorbable sutures entirely. He saw only one case in which the non-absorbable sutures came out and that was due to infection.

He stated that he did not use non-absorbable suture material. He was surprised to hear Doctor Torek say that he used No. 3 chromic catgut. He himself never used at the present anything larger than No. 1. If he needed an additional strength he used No. 1 chromic catgut taken double.

In regard to the saddle-bag sac, one can convert the direct sac into an indirect sac by pushing the deep epigastric vessels toward the middle line while pulling the peritoneum outward. Then the sac can be closed by a running stitch as in any indirect hernia. Doctor Downes was one of the first whom he had seen use this method.

In making the muscular repair he makes his first stitch in the edge of the sheath of the rectus which he sews to the periosteum over the

spine of the pubis. The external oblique he believes in closing so tightly that there is no chance of a subsequent examiner finding a large external ring and interpreting it as an incomplete repair.

DR. CHARLES H. PECK said that he did not agree with Doctor Torek about the separation of the vessels and the vas, nor upon the use of non-absorbable suture material, but he has paid much attention to a clean and careful technic and good apposition of tissues. He thought the paper could profitably be placed in the hands of every house surgeon.

Doctor Torek, in closing, stated, in regard to the relative position of the vessels, sac, and vas, that, of course, he referred to their relation at the internal ring. Outside the internal ring their relative position varies, but at the internal ring the anatomical arrangement is as stated in the paper. A dissection well down to the posterior surface of the transversalis fascia will convince one of the fact. That fan-shaped expansion which Doctor Coley referred to consists of connective tissue the presence of which conceals or blurs the actual relation of vas and vessels to the sac. In Doctor Torek's operation this connective tissue expansion is removed, and, if this is done, one will find the anatomical arrangement as he has described it.

As to whether he had seen these cases lately, he said that all the cases reported in this series had been seen within the last five months by himself or some other competent observer.

In regard to the percentage of cases in children and adults, he had almost no children in this series. That fact should be taken into consideration in comparing these statistics with those of a children's hospital, as in cases of children the result of a hernia operation is apt to be satisfactory no matter which one of the standard operations was performed.

As to the statement that he was making two weak points instead of one, he did not think one would claim this to be the case after inspecting the line of sutures. The vas takes up so little space where it emerges that the suture above it is just as close to the suture below it as any other two adjacent sutures.

As to the use of non-absorbable suture material, he said his opinion was shared by many good surgeons. However, he wished to lay emphasis on the use of non-absorbable material only where there was tension. In the absence of tension he does not insist on it. As the value of absorbable suture material had been mentioned in the discussion, he would like to relate a few experiences with chromic catgut. He had had occasion to operate on a patient on whom he had performed a laparotomy two years previously. Going in through the old scar he found a number of chromic catgut sutures which had been inserted two years before. He also mentioned that in his operation of orchidopexy for undescended testis he had always employed chromic catgut in attaching the testis to the fascia of the thigh; and when the testis was released six months later, in three cases he had found chromic catgut still unabsorbed. He said,

the label on the tube, stating that the gut is twenty or forty day catgut, is not to be relied upon—it may be two year catgut.

COMPARATIVE MERITS OF LANE PLATES AND INTRAMEDULLARY BONE SPLINTS

DR. JOSEPH WIENER presented röntgenograms of a boy ten years old, who was admitted to Mt. Sinai Hospital, April 29, 1918. He was thrown from his bicycle by a passing automobile and sustained a fracture of the lower end of the femur. On examination the left lower limb was found slightly abducted and the foot everted. There was a false point of motion about three inches from the knee. Buck's extension was applied. Shortening of limb persisted and X-ray showed that overriding continued.

On May 17, 1918, the boy was put on the Hawley table; a Steinman nail was inserted into the head of the tibia but traction failed to reduce the fracture. An incision was then made and an overriding fracture with soft callus was found. The callus was removed and a Lane plate introduced. Wound was closed without drainage and healed by first intention. The plate is still in place after eleven months. The boy is very active and has no symptoms whatever from the presence of the plate.

Doctor Wiener then presented radiographs of a patient, twenty-three years old, who was admitted January 13, 1916. Seventeen days before was struck in left arm by street car. When he recovered from the shock there was complete loss of function of the left arm, together with pain and swelling. The arm had been put up in splints with no attempt at reduction. His pain grew steadily worse until his admission to Mt. Sinai Hospital. On examination he found marked swelling and deformity at the lower third of left humerus. Flexion at elbow was possible but extension was impaired. Flexion angle 60° ; extension about 20° . Distal end of bone could be felt on inner side of arm.

Operation (January 17, 1916).—Intramedullary bone splint for ununited fracture of humerus. Five-inch incision on outer aspect of arm just above elbow. Fragments found displaced exactly as shown by röntgenograms. Ends of bone freed from muscles in which they were imbedded with great difficulty. About $\frac{1}{4}$ inch was sawed off the end of each fragment. It was impossible to keep the fragments in apposition on account of flexion of lower fragment which was less than two inches long. A bone inlay $2\frac{1}{2}$ inches long was taken from the tibia on same side with its periosteum attached. The medullary canal of both upper and lower fragments was scraped with a sharp spoon and with considerable difficulty the inlay was introduced. The ends of the inlay were denuded of periosteum. The periosteum which had been stripped from the fragments in freeing them was carefully sutured with chromic gut over the line of union. The remainder of wound was sutured without drainage. The wound healed by primary union. New bone rapidly formed and the ultimate result was functionally and cosmetically excellent.

Doctor Wiener presented these röntgenograms for the purpose of inviting discussion as to the relative value of the Lane plate and the intramedullary splint. It has been his habit not to use the bone splint in difficult cases because it breaks. He had one case in which it took two members of the house staff, strong young men, to keep the femur in place. He put a Lane plate on the outside of the bone and another plate on the inside. The following day plate No. 1 on the outside had broken, but he obtained a good result because plate No. 2 held. He thought an intramedullary bone splint would certainly have been perfectly useless in that case.

Stated Meeting held April 9, 1919

The President, DR. CHARLES H. PECK, in the Chair

MYOMA OF THE SMALL INTESTINES

DR. FRANK S. MATHEWS presented a woman forty-four years of age, two years past the menopause. She had come to his office several weeks before, complaining of mitral stenosis and stating that a hypogastric tumor had been noted quite recently. On examination, the tumor was found irregular, hypogastric and more to the left side. On bimanual examination the cyst ruptured. In a few minutes the patient's pulse became slow and weak, pain was severe and there was cold, clammy skin. She was taken to the hospital immediately and after a short application of external heat, she was taken to the operating room. He was expecting to find a ruptured cyst of pelvic origin, but was surprised to find that the cyst had no pelvic attachments and that the pelvic organs were normal. The abdomen contained considerable bloody fluid. The tumor had a small attachment to the side of the small intestine opposite the mesentery. It was cystic and solid and there were abundant evidences of previous hemorrhages into the mass. It was dissected from the bowel without resection, a small tear being made in the mucosa. Its origin was from the lower ileum, and possibly originated in a Meckels' diverticulum, as it lay entirely opposite the mesentery and was supplied with blood by two arteries from the mesentery which crossed the wall of the gut. The tumor proved to be a myoma of the smooth-cell variety. Before rupture of the cyst, the tumor would have measured seven or eight inches in diameter. Recovery was uneventful.

Doctor Mathews emphasized the infrequency of such myomata except in the uterus; he thought its probable origin to be at the site at which a Meckels' diverticulum is found; the rupture of the cyst from the trauma of very gentle manipulation, with immediately following severe symptoms, was also deserving of note.

DR. HERMANN FISCHER said that about eleven years ago he operated upon a fibro-lipoma of the stomach situated at the lesser curvature in a girl twenty years old. She complained of rather severe stomach symp-

toms without definite clinical findings pointing to a lesion of the stomach. On careful examination a small epigastric hernia was detected and held responsible for her distress. On operation the stomach was also inspected and to our surprise a tumor at the lesser curvature was found. A V-shaped resection was done. The mucous membrane was not involved, the seat of the tumor being the muscular wall. Microscopical examination showed the mass to be a fibro-myxo-fibroma with inflammatory changes.

Ten days after operation the patient developed a rather severe attack of tetany from which she, however, eventually recovered.

DR. JOHN A. HARTWELL said Doctor Rogers had a similar case of myoma of the lesser curvature. In that case the tumor was definitely myomatous, not pedunculated, and gave symptoms closely simulating those of gastric ulcer.

DOUBLE EMPYEMA—STREPTOCOCCUS HÆMOLYTICUS

DR. JOHN A. HARTWELL, for the purpose of introducing a discussion on the general topic of empyema, presented a young man who was admitted to the Medical Ward of Bellevue Hospital on December 16, 1918. He was transferred to the Surgical Ward eleven days later. He had a typical streptococcus pneumonia and consolidation of the right base, and there was evidence of fluid in the right pleural cavity. The patient was operated on by Doctor Dudley on the right side on the same day. The pleural cavity was opened through an incision in the right axillary line and a rib resected. A large amount of thick purulent fluid was evacuated which toward the last became blood stained. It gave a pure culture of streptococcus hæmolyticus. Carrel tubes were inserted and Dakin's solution used until the discharge became almost like pure blood, then this was discontinued. The patient progressed favorably though slowly for about three weeks and then became desperately sick, owing to his continued general infection with the streptococcus. The discharge became less and he was gradually gaining when he developed empyema on the left side. Three radiographs showed that the empyema had localized in the lower portion of the left chest. A second operation was performed on February 3, six weeks after the first, a rib resection similar to the first being done. On this side the ordinary method of drainage was employed and there was no washing or any other method of local treatment; the use of blow-bottles and calisthenics was begun early and seriously carried out. Both sides healed up and the man went to the Burke Foundation. He has recently returned and physical examination showed no abnormality. Radiographs showed both lungs fully expanded. He was a completely healed and cured case of double streptococcus empyema.

His only reason for showing the case was that one has here a case in which there was empyema on both sides; on one side Dakin's solution

was used and not on the other. The side on which the Dakin's solution was used did not heal up any more promptly than the other side treated with the old-fashioned simple drainage. They have been running a series of cases, one-half with incision and simple drainage and the other half treated with Dakin's solution through Carrel tubes in addition to complete drainage, putting the tubes in at the time of the operation or twenty-four to forty-eight hours afterward. In the pneumococcus empyemas he thought this treatment was beneficial, where the pus is thick, but in cases of the hæmolytic type he does not feel that it does much good. With the use of Dakin's solution the time of healing was not shortened as compared with the average cases in which Dakin's solution was not used. With Dakin's solution, however, there was less tendency for the cases to continue longer than the average time and there was a more uniform result with the Dakin treatment. The question of treatment rests very largely on the type of disease with which the surgeon is dealing. In many cases the empyema is only an expression of a general infection, and if one operates early one still deals with a general streptococcus condition and one does not accomplish much. This case was presented to focus attention on the fact that the old method of treating empyema gives exceedingly good results, if the details of ample drainage and careful after-treatment are carried out. In contrast, however, there was at present on the service a case of pneumococcus empyema handled in the same way which was still unhealed after more than ten weeks. A complicating factor, however, existed in the fact that at the time of the first operation an open communication via the lung was present between the bronchi and the pleura. So far as can be determined this has closed but it interfered with the orderly course of events at first. Thus illustrating that in all discussions on the treatment of empyema a strict interpretation of the lesions must be kept in mind.

DR. HOWARD LILIENTHAL said if one has a unilocular empyema not complicated with a bronchiectasis or a lung abscess it may heal in one of two ways. It may heal from the outside with sterile pus within, the lung gradually becoming distended until in time it reaches the costal pleura, or it may heal with the gradual formation of adhesions all around the lung, coincidentally reaching the costal pleura. If it does not heal in one of these two ways it will remain open with a sinus. If one should fluoroscope such a case and the lung does not move pretty distinctly one will probably be obliged to operate unless complete asepsis can be secured. We have tried various methods of disinfection and it does not make much difference what method one uses. In an empyema thus closed accidents may happen. A serious accident is the slow perforation into a bronchus, and one would not know that this has happened until the patient coughs up and one then has the additional complication of a bronchial fistula.

He has X-rays of the chest of a young girl who had a sinus that opened and closed periodically. The X-ray showed an almost complete

pyo-pneumothorax and a great space in the lung compressed. The girl looked well and he thought he would see what could be done for her without operation, so he sent her to the country and told her mother that if the sinus opened again he would operate. Nearly a year after the girl returned and the X-rays taken at that time showed both sides so nearly alike that it was difficult to say which side had been affected.

It is not absolutely necessary to have the lung in complete adhesion with the chest wall in order to have an absolute cure. It is possible in unilocular empyemas to have cures with the Carrel-Dakin treatment if one is sure one is dealing with a unilocular empyema, but in that child he was unable to use the fluoroscope because the thorax was closed and if the thorax is closed the lung cannot obliterate the pneumothorax. He has been trying to make up his mind which cases were suitable for operation but has not quite decided whether or not it was wise to let the wound heal, provided, of course, the empyema was a unilocular one.

DR. JAMES I. RUSSELL said he recently had a case of empyema on both sides in a child ten years old. She was so ill that it was a question whether best to treat her by aspiration or by drainage; and whether, if establishing drainage, which side, or whether both sides of the chest should be opened simultaneously. Aspiration was first tried, but she continued to grow more septic. The rib was resected on the right side under nitrous oxide, and a few days later the left was similarly treated. Dakin's solution was used in this case with apparent good result.

In the use of Dakin's solution he has seen an interesting series of cases, some that were still unhealed from the 1917 epidemic, and the more recent ones that followed the influenza epidemic last fall. He does not think that it has any specific action other than as a solvent; and when there is the thick tenacious discharge, it is certainly very valuable. Patients frequently complained of the taste of chlorine when the wound was irrigated, which was undoubtedly due to the entrance of the fluid into the small pin-point perforations of the lung which are often overlooked in empyema.

From the study of X-ray plates he felt sure that empyema was not always a single abscess cavity, but was frequently loculated or multiple cavities formed just as peritoneal abscesses, from a general peritonitis.

DR. LILIENTHAL called attention to the fact that empyema was not usually unilocular; there are very frequently pockets, often minute ones. He thought such abscesses were less likely to go undiscovered. If the main cavity is opened early by a minor operation to give an exit for the pus, then a few days later after X-ray study one can operate as indicated by the condition. One can do this through an intercostal space, without the resection of one or more ribs, by making an intercostal incision and separating the ribs by strong rib retractors. One should bear in mind the fact that one may have a number of empyema abscesses in one patient. He recalls one instance in which the patient had four

CARCINOMA OF THE RECTUM

abscesses, one at the apex, one at the outer side of the lung, one in an intercostal space and one in the lower lobe. Smaller abscesses are often likely to break into a bronchus than into the main cavity.

DOCTOR PECK said he has a prejudice against open pneumothorax. He thought a great deal can be accomplished by air-tight drainage, if the drainage is early and adequate. Too often the ordinary surgical principles of drainage are not carried out intelligently. If one gets a good air-tight drainage in these cases and then leaves them alone for eight or nine days, beginning the use of blow bottles at once, very good results are obtained without the use of Dakin's solution, and there is little soiling of the primary dressing which may often be left without changing until the tube is removed. He has had a number of cases in which this principle was carried out. After the drainage tube was in eight or nine days, in many of these cases the pleural cavity was almost closed and there was complete healing in five or six weeks. Of course this does not happen in every case but it does in many. The trouble often is that ordinary drainage is not properly carried out and this is the reason one sometimes later has a thickened pleura and persistent cavities. As the wound gets older the rate of healing diminishes.

RHINOPLASTY FOR CARCINOMA OF THE NOSE

DR. FRANZ TOREK presented a patient with carcinoma of the nose. The case was one of a large fungating tumor requiring the removal of the greater part of the nose and septum. The object of this presentation was to show that a fairly satisfactory result could be obtained by a rather simple plastic operation. There was no implantation of bone or cartilage and yet the skin flap taken from the forehead showed a remarkable degree of firmness, scarcely distinguished from that of cartilage, although it had no support from the septum. The flap had been made long enough to be doubled on itself, thus providing an inside lining of skin, the two layers of skin being attached to each other by a couple of mattress sutures. The reduplication of the flap, it appears, was accountable for its firmness, while at the same time it provided a well finished margin. The outer border of the ala showed a particularly happy imitation of the normal.

CARCINOMA OF THE RECTUM—COMBINED ABDOMINO-SACRAL OPERATION

DR. FRANZ TOREK presented two patients in which a combined abdomino-sacral operation had been performed, and no artificial anus made, and still the patients have the control of a normal anus and the result of the operation was perfectly satisfactory in both cases.

He showed a case and described the operation in the ANNALS OF SURGERY of November, 1917. Briefly the operation consisted in an abdominal portion and a sacral portion. The abdominal operation consisted in the mobilization of the sigmoid, loosening it and the pelvic colon

and rectum down to the pelvic floor. The important point in this part of the operation was to mobilize without endangering the blood supply. The inferior mesenteric usually has three sigmoid branches, the lowest being given off when the inferior mesenteric becomes the superior hemorrhoidal. The latter divides into several small terminal branches which anastomose very imperfectly with the branches of the sigmoid artery. To mobilize the sigmoid flexure, therefore, the inferior mesenteric must be divided above the point where the lowest sigmoid branch is given off in order to provide for a sufficient blood supply to the pelvic colon and rectum, the supply running through the lowest sigmoid in a backward direction to its origin, thence down through the superior hemorrhoidal. The point of ligation is about an inch above the insertion of the peritoneal fold at the promontory of the sacrum. The sigmoid flexure, pelvic colon, and rectum are liberated and pushed well down into the pelvis, ready to be attached in the subsequent part of the operation. An incision is then made along the side of the coccyx to the lower part of the sacrum and the rectum mobilized and invaginated or rather evaginated through the well-stretched sphincter, and then amputated at the anus and above the tumor, the upper segment being sewn to the anus. The really important point is in regard to the blood supply, as he has explained in his published article. The third sigmoid artery is the one that gives the blood supply, and one must not cut the superior hemorrhoidal below the point where the last sigmoid artery is given off, for if one does, the anastomosis is imperfect, and one may get gangrene.

In this first case a scar had formed in the rectum which looked as though it might be a stricture. This helped the patient to control the escape of feces. She takes an enema every day and is very comfortable.

The second case is a duplicate of the first, differing in one point only. He advised this patient against operation because the carcinoma was so low that he feared a radical resection could not be done without taking away the whole sphincter, but the patient insisted on an operation without artificial anus and persuaded him to try it. In this he cut through the sphincter and laid it back, dissecting the rectum from it, after which the affected portion of the bowel was amputated. After suturing the cut end of the bowel to the anus, he then resutured the sphincter where it had been divided, although he thought there would not be sufficient innervation to give the patient any use of the sphincter. He had, however, some sphincteric action and had no inconvenience from his stools. He takes an enema once a day and sometimes skips a day. One always fears the inconvenience of escaping feces when one divides the sphincter, but there has been no such inconvenience in this case.

DR. JOHN A. HARTWELL said in examining these patients of Doctor Torek his impression was that the man has carcinoma at the present time and he thought the woman also. She has a dense cicatricial point that seems as though it were a recurrence.

A number of years ago he collected cases operated upon by the sacral method without an inguinal colostomy by seventeen surgeons and practically all had local recurrences within two or three years, and in many instances the recurrence was very prompt. He asked Doctor Bull to look over his paper and he said it was a good piece of work but that Doctor Hartwell had wasted a great deal of ammunition in demonstrating a self-evident fact, etc. One could not expect to cure a carcinoma of the rectum in that way, as there was not a wide enough incision below the growth where any attempt to save the anal margin was made. He recognized that recurrence was very frequent in all cases of carcinoma of the rectum, but there was always a local recurrence after the method under discussion.

DR. WILLIAM LUSK said that the implantation of the freed proximal sigmoid extremity of the gut into an intact anal canal was very likely to be followed by gangrene of the implanted segment.

DR. HOWARD LILIENTHAL said as to the operation suitable for carcinoma of the rectum he thought it was a matter of the artistic choice of the surgeon. He believed that in small sized cicatricial carcinoma, well localized and situated in the right locality for that procedure, it was the best operation that could be done. He reported a case a year ago before the American Surgical Association in which he did the operation a little differently than the one done by Doctor Torek. He made his abdominal incision and loosened the sigmoid. The carcinoma was situated at the rectosigmoid junction. He passed in a probe carrying a silk ligature. Then by stretching the anus he pulled the whole tumor-bearing region out of the rectum and managed to do a wide excision. The man recovered and when he left for France he was perfectly well. He has seen him since his return and he is still perfectly well and has no sign of recurrence. That was a case in which he decided what he would do after he had explored it from the abdominal side. The tumor was small and admirably placed for this kind of an operation. This man has no sign of a stricture. There is perfect function.

DR. WILLY MEYER said that if one preserves only one or one and one-half inches of the rectum with the sphincteric portion, one must look for a recurrence. He thinks the majority of surgeons agree that one must sacrifice the sphincteric portion in order to get radically rid of tumor. For a constricting tumor he considers cæcostomy through a McBurney incision a good method, as the first step in a two-stage operation. But it is not necessary to establish an artificial anus in every advanced case. The degree of constriction decides. Several days of preparation are then required. After amputation a sacral anus is established or the lower end stitched about one inch below the surface of the skin of the perineal wound. He had one patient thus operated upon about eight years ago. With an enema in the morning he keeps himself com-

fortable and clean for days. Twisting of the stump before suturing, after Gersung, offers additional advantages.

DR. CHARLES H. PECK stated that he had a case of this kind done about ten days ago and he had seldom done the operation under more favorable circumstances. This patient had a long lax sigmoid and he did practically the operation Doctor Torek has described. He would like to say that in that case he does not see how the danger of recurrence can be greater than in other methods. The bowel was divided at least three inches above the growth, the upper rectum and mesosigmoid were mobilized and the entire hollow of the sacrum cleaned out. The entire anal mucous membrane was removed and the sphincter split behind. The end of the sigmoid was brought down on a level with the skin edge. He thought with this procedure there is no added danger of stricture and that the only question was that of recurrence and that was a question of going high enough above the growth to avoid a recurrence in the proximal segment. The cases in which this procedure can be safely done are few.

DOCTOR HARTWELL said he thought it was in the lower segment that there is the greatest danger of recurrence.

These cases are apt to recur below the point of resection when an attempt is made to leave an inferior functioning segment. There is not room enough between the anus and the growth to make it worth while to attempt to save the anal outlet, if one is certain all infected tissue is removed.

DOCTOR PECK said that two or two and one-half inches of the gut below the growth was removed with the entire anal mucous membrane. He did not expect to get a great deal of sphincteric action. He thought if he took away all the tissue that it would be an advantage to remove. This type of resection is only suitable when the growth is high enough up to allow for a good clearance.

DOCTOR TOREK, in closing, said all three cases had strictures and these strictures instead of being a drawback have been a comfort for they hold the contents of the bowel sufficiently well to have the effect of a sphincter and then by the simple method of taking an enema once a day the bowel is cleaned out completely. You see a stricture has formed in every one of these cases. He shall not hesitate to do the operation where the entire sphincter has to be removed. The operation may be done just as radically by this method as by any other, and there is no question that the combined operation has many advantages over the operations done from below only, because when one opens the abdomen and finds metastases in the liver or in the peritoneum he knows there is no use of attempting a radical operation. By doing the abdominal operation first, one at once can draw the line between cases that are operable and those that are inoperable.

As to sloughs he always feels quite positive that they are caused by

RARE PATHOGNOMIC SYMPTOM OF CHOLECYSTITIS

drawing the gut through the sphincter because the sphincter is widely stretched. If there should be sloughing it would be from interference with the blood supply and not from constriction by the sphincter.

CARCINOMA OF THE TONGUE—COMPLETE EXTIRPATION

DR. FRANZ TOREK presented a patient who was operated on three years and four months ago for carcinoma of the tongue and presents several points of interest. Examination shows that there is no trace of tongue to be seen. The floor of the mouth was removed at the same time. This threw the hyoid bone forward and one can see the epiglottis. The second point of interest is that the two halves of the lower jaw are drawn toward each other. Of course, all the lymphatic nodes were removed all along the sternocleidomastoid and the submaxillary nodes. He did a Kocher's operation with the division of the jaw in the middle. The two portions were not in proper alignment and overlap in the middle, owing to necrosis at the sawed surface and scar contracture at the floor of the mouth. The third point is that this patient speaks very well, even such consonants as s and l and he has a very good cosmetic result. He was operated on December 29, 1915. It was interesting to see how a person with absolutely no trace of tongue could learn to speak and do without such an important organ. The fourth point was that of a late recurrence, three years and three months after the operation in a node above the outer end of the clavicle which he removed recently. He has no evidence of recurrence in the mouth, nor in the submaxillary and sternocleidomastoid regions. When he was first seen by Doctor Torek, the floor of the mouth and both sides of the tongue were involved along the edges. If only one edge had been involved he would have removed only one-half of the tongue. It was a case in which there was very little hope of keeping the man alive as long as he has now lived.

RARE PATHOGNOMIC SYMPTOM OF CHOLECYSTITIS— CHOLECYSTECTOMY

DR. WILLY MEYER presented a patient because she presented a rare pathognomic symptom of chronic cholecystitis. She was an Italian, thirty-three years of age, who had had for quite a number of years attacks of pain, always on the left side of the upper abdomen corresponding to the costal arch, and radiating down to the left of the abdomen. Also to the back and left shoulder, but never to the right and never toward the liver. He had seen patients with similar symptoms at his office, in whom he could not ascertain what the trouble was. He had thought of ulcer of the lesser curvature, chronic pancreatitis, or a kidney lesion, but could not make the diagnosis; they refused admission to the hospital and drifted away from him. This patient came with such a distinct record of attacks reminding him of chronic cholecystitis. She was sent to the hospital for laboratory examination. All the usual ex-

aminations were made, except that of the duodenal contents. While in the hospital she had pain for the first time that was radiated from left to right.

At operation the gall-bladder, filled with stones, was found low beneath the liver so that it could not have been palpated. Perthes' incision was employed. The skin incision may look large but the real abdominal incision is comparatively small. The speaker stated he had used this incision about thirty-five to forty times and the oftener he did it the better he liked it. It gives ample space for exploration of the intra-abdominal organs enabling one also to explore and remove the appendix. It is especially suitable for giving access to the lower aspect of the liver. He had used it in all kinds of operations on gall-bladder and ducts, also in one case of periduodenal abscess. There is never a sign of ventral hernia later.

The examination of the duodenal contents is a very welcome addition to our diagnostic resources. The X-ray fails in many cases to give sufficient pathognomic signs of gall-bladder disease. Some have claimed that the diagnosis of cholelithiasis can be made in 30, 50 and even 80 per cent. of the cases, but he thinks the rays can make a positive diagnosis in only 15 or 20 per cent.

Examination of the duodenal contents may show the presence of pus corpuscles, cholestearin, putrid bile, etc. During operation the gall-bladder is aspirated and the color of the bile obtained compared with that found in the duodenal contents. One will find that it almost invariably corresponds and hence the examination of the duodenal contents gives a good idea of the real condition of the bile. The particular point desired to be brought out in this patient was that if a patient comes with paroxysmal pains in the extreme left side and the same runs to the back and also to the left shoulder, one has also to think of cholecystitis. Patients with cholangitis are always jaundiced, though sometimes but slightly, but those with cholecystitis that he had been talking about are not jaundiced; they are discharging their bile physiologically into the abdomen and if one examines the duodenal contents one can get points on the diagnosis that are of value.

LOTHEISEN OPERATION FOR FEMORAL HERNIA

DR. HERMANN FISCHER read a paper with the above title, for which see p. 432.

Doctor Fischer presented three cases for the purpose of illustrating his paper. The results in all three are good. If the patients are examined in the erect posture and made to strain, one will notice that at the point of the operation there is a distinct inward pull of the abdominal musculature instead of the usual bulging outward.

DR. WILLY MEYER said the operation described by Doctor Fischer is very similar to the operation proposed by Fabricius, of Vienna, in 1894. The latter also makes an oblique incision, but, instead of one-quarter of

an inch above Poupart's ligament, one-quarter of an inch below the same. Poupart's ligament is exposed, the hernia properly attended to, and the crural ring thoroughly cleared of its contents. One then tries to bring the ligament down to the tissues to the inside of and next to the vessels. The femoral vein is exposed and pulled outward. A well-curved needle is introduced down to the pubic bone; one tries to catch its periosteum stitches the pectineus muscle to Poupart's ligament. The space next to Gimbernat's ligament is entirely obliterated. The first outer suture must be carefully placed to avoid compression of the vein. This operation of Fabricius can also be highly recommended. The speaker has repeatedly brought patients thus operated on before the society.

DOCTOR TOREK said the operation of Fabricius was surely not identical with the Lotheisen operation. Fabricius brought Poupart's ligament down to the pectineus muscle while Lotheisen brings the internal oblique into contact with Cooper's ligament. The Lotheisen operation has been his choice ever since it was published. It was technically somewhat difficult to gain access to Cooper's ligament, since it was rather deep. In his first case of this operation he cut through Poupart's ligament in order to gain better access to Cooper's ligament, and then he sewed up Poupart's ligament again. He found that it was unnecessary to cut through Poupart's ligament, and that the suture was feasible with fair ease if a properly curved needle was employed. One must carefully guard the femoral vein. It was always best to lay it bare and draw it aside to a certain extent but never so far as to compress it.

DOCTOR FISCHER said, in answer to Doctor Meyer's remarks, that the Fabricius operation and the Lotheisen are not the same, but differ radically from each other. Fabricius closes the femoral ring by uniting Poupart's ligament to Cooper's ligament, similar to the Moschcowitz-Frank operation. In Lotheisen's operation the conjoined tendon is sewed to Cooper's ligament; Poupart's ligament is not at all used for the plastic closure of the femoral ring. The Lotheisen operation is especially useful in large and strangulated or irreducible femoral hernias in which one is compelled to divide Poupart's ligament. Of course, it is a well-known fact that a femoral hernia is often cured by the simple Bassini operation, but these are uncomplicated cases of small size, the large complicated ones easily recur. In the Lotheisen operation the sac is also tied off as high as possible.

DR. NATHAN W. GREEN said he had done a number of femoral hernia operations according to the Ruggi method which in some respects is similar to the Lotheisen. It seemed to him the operation was excellent but more elaborate than the simple high ligation of the neck of the sac with stitching the posterior part of Poupart's ligament to the pectineal fascia. He said he generally took two stitches at this point, then if one gave way the other still held. He thought this a simpler way of repairing femoral herniæ and it appeared quite adequate as they seldom recurred after this ordinary procedure.

BOOK REVIEWS

SURGICAL ASPECTS OF TYPHOID AND PARATYPHOID FEVERS. By A. E. WEBB-JOHNSON, D.S.O., Consulting Surgeon British Expeditionary Force, Hunterian Professor of Surgery, R.V.S.E. London, Oxford. University Press, 1919, octavo, cloth, pages 190.

This is an amplification and revision of the Hunterian Lecture for 1917. The Director General of the British Army Medical Service, Lieut.-Gen. T. H. Goodwin, opens the book with the remark that, with the exception of Keen's book, written in 1898, comparatively little literature has been contributed to the subject on the surgical complications and sequelæ of typhoid fever, notwithstanding that perhaps as an influence upon armies in the field it is probable that typhoid and paratyphoid fevers have had a greater part than any other group of diseases. The author himself in his own preface states that, although twenty years have elapsed since the publication of Keen's book, it was dealt with so thoroughly by that surgeon that all that was called for at the present time was a consideration of new problems, with a review of advances in our knowledge consistent with our present conception of these fevers and with modern surgical practice. The book was compiled under war conditions and was primarily intended for the information and use of the surgeons of the British forces in the field.

The author is evidently interested in the history of medicine and medical biography, as shown by the very attractive historical sketch which constitutes Chapter I of the book, which is illustrated by many portraits of surgeons who have made important contributions in the past to our knowledge of typhoid fever, beginning with Thomas Willis, who was serving King Charles I in the Cromwellian Wars when the Royalist forces, as well as the parliamentary troops, were both alike decimated by an outbreak of disease which was described in detail in Willis's work "*De Febribus*" so fully as to leave no doubt that the fever which prevailed was typhoid. In the next generation, the eldest son of James I, Prince Henry of Wales, died of typhoid fever and an excellent and rare portrait of that prince is given, followed by that of his physician, Sir Theodore de Mayerne, whose account of the prince's illness and the description of the appearances found at post-mortem are so full and accurate that there is no difficulty now in recognizing that the illness was typhoid fever. The death of Prince Albert from typhoid fever does not escape mention, which mention is accompanied by a portrait of Sir William Jenner, who attended Prince Albert in that illness and also in the illness of his son, the Prince of Wales, who afterwards became better

known to history as King Edward the Sixth, who nearly died from the same disease ten years after the death of his father.

Perhaps the most interesting of the portraits given in this historical sketch is that of William Clift, since the medical public is not so familiar with this portrait as it is with those of his better known superiors, John Hunter and Matthew Baillie. The last two portraits in the chapter are, respectively, those of Sir James Paget and of William W. Keen.

The association of these personal sketches in this historical chapter constitutes a peculiar attraction to the book and alone should suffice to make it popular.

The text of that portion of the book devoted to the special theme is comparatively brief. Of especial interest is the tabulated statement in which are given 103 causes of death due to surgical complication of typhoid and paratyphoid fever in 2500 cases of these diseases. The mortality attending the paratyphoid types (A and B) is almost negligible. The difference between the mortality following typhoid of spontaneous origin and typhoid produced by direct inoculation is very marked, spontaneous typhoid having a mortality of 19.19 per cent., and that of the inoculated form only 3.28 per cent. of the fatal results. Of the 103 deaths 67 were due to hemorrhage; 14 to perforation. Of other surgical complications not necessarily fatal, the most frequent was venous thrombosis, 42 cases of which are here recorded. Many negative complications appear in the list, such as 37 cases of tonsillitis; 17 cases of laryngitis; 15 cases of cholecystitis; 11 cases of appendicitis; 3 cases of abscess of the spleen; 2 cases of abscess of the liver; 3 cases of abscess of the lung; 2 cases of empyema; 22 cases of other abscesses.

In the subsequent chapters the author takes up in succession the lesions, first of the alimentary tract, then of the spleen, then of the liver, biliary passages and pancreas.

The chapter devoted to the cardiovascular system is one of the most important of the series, as is evident from the large proportion of thromboses in the tabulated statement. Thrombosis plays a part in the origin of bedsores and in cases of gangrene about the face and external genitals.

Gangrene of an extremity is a well-known though rare complication. Excluding bedsores, the legs and neck suffered from gangrene more frequently than all other parts of the body put together, with equal frequency upon the two sides.

Venous thrombosis, even though it may not call for so serious an intervention as amputation, may lead to serious disability. Not only is convalescence prolonged, but the circulation in the limb may be permanently damaged. Varix may develop or there may be such a persistency of œdema as to cause permanent weakness and disability of the

limb. In case of obstruction of the external iliac vein there may develop in the abdominal wall large and tortuous veins in the effort to compensate the obstruction of the venous return from the lower extremity. The incidence of venous thrombosis is commonest in typhoid, is fairly frequent in paratyphoid A, least frequent in paratyphoid B. The femoral vein is the one most commonly affected and in the present series there are 25, 10 in the leg, 5 in the iliac, 4 in the popliteal, and 3 in the internal saphenous vein. There was no case of thrombosis in the upper limb, though this may occur. The left lower limb was affected in the majority of cases, a preponderant frequency referred by Keen to the obstruction to the return of venous blood by the compression of the left common iliac vein where it passes under the right common iliac artery.

Of the present series which suffered thrombosis, only one died, death being due to the toxæmia of the disease, although the thrombosis was not entirely free from agency in contributing to the fatal result, the post-mortem showing present many infarcts in the heart, lungs and kidneys.

With regard to the effects of the typhoid bacilli upon the urinary system. In a large number of cases the bacilli appear in the urine in typhoid proper, in about one-fourth of the cases; in paratyphoid, a proportion much less. Albuminuria to a more or less degree occurs in 60 per cent. of all cases. Pyelitis and cystitis were definitely diagnosed in a small group of cases. They yielded rapidly to treatment, urinary antiseptics in the series studied by the author. No case of kidney complication required local surgical treatment.

Parotitis is a serious complication. It is fortunately rare, in the present series of cases having occurred only in about one-third of 1 per cent. of the cases. Two of these cases were fatal. With one exception all of the cases of this series were unilateral. The gland was incised in 6 of the 9 cases, but in two of them no pus was found, a not uncommon experience in cases of secondary parotitis. Nevertheless, in view of the dangers of the condition, incision should be made without waiting for fluctuation, when the swelling increases or the œdema appears. The author is of opinion that present evidence warrants the conclusion that the parotid is infected by extension from the mouth through the parotid duct.

Bone and joint complications receive full treatment.

The book as a whole is an interesting résumé of present knowledge with regard to the surgical aspects of typhoid and paratyphoid fevers. It belongs to the class of war medical and surgical tracts, the large number of which bears testimony to the activity and earnestness of efforts to secure the highest possible degree of efficiency in bringing surgical relief to the soldiers of the allied forces during the recent war.

BOOK REVIEW

THE AFTER-TREATMENT OF WOUNDS AND INJURIES. By R. C. ELMSLIE, M.S., F.R.C.S. Philadelphia, Pa. Blakiston Son & Co. Cloth; octavo; pages 323.

The title of this book is not fully descriptive of its field. The Treatment of the Late Results of Wounds and Injuries is, perhaps, more descriptive of the real contents of the book. It cannot be classed as a book on Orthopedic Surgery, although discussion of the treatment of deformities is an important part of it.

After some discussion of the principles of reparative surgery, the author discusses the treatment of chronic osteomyelitis, stating that chronic sinuses of bone are, perhaps, the most frequent sequels of a wound and, in most, important causes of delay in reparative work. In cases of this condition he follows the radical methods advocated by Broca, which he reports in his hands to have been most successful.

In cases of sinuses leading to bone, he says the incisions must be made of sufficient length to enable the bone to be exposed above and below the injured site, even if this necessitates an incision 10 or 12 inches long. The periosteum must be stripped back from the whole circumference of the bone. Every track and cavity in the bone must be thoroughly explored and every tunnel and every cavity must be scraped and chiseled until it lies flat and no longer makes a groove and there remains behind only healthy bone or callus. If, however, the cavity is of such depth that it can not be laid quite flat without endangering the strength of the bone, it may be converted into a gutter into which the soft tissues can fall. Though the extensive removal of bone in these radical procedures may appear to endanger the shaft of the bone, no hesitation should interfere with its performance.

Ununited fractures next come under consideration and are treated fully and most satisfactory in Chapters III and IV. This involves the subject of bone graft to which especial paragraphs are devoted. Stiff joints and flail joints follow, and then the results of injuries of nerves and the surgical treatment indicated.

Amputations are considered from the standpoint of the best functional results and the adaptability of the stumps to prosthetic appliances. Various considerations involved in the repair of wounds of the upper limb, and then of the lower limb, are fully treated and form an important and interesting part of the book. Paragraphs are then devoted to splints and surgical appliances and to plaster-of-Paris. The volume is closed by a chapter devoted to such matters as baths, massage, passive movements, radium, X-ray, etc.

This brief résumé of its contents shows how important are the subjects which are treated, all having a particular bearing upon the possibilities of restoration to some activity to wounded men. The subjects are well treated, and fully described. The book is fully illustrated.

LICE AND THEIR MENACE TO MAN. By LIEUT. L. LLOYD, R.A.M.C., Entomologist in Northern Rhodesia. With a Chapter on Trench Fever by MAJOR W. BYAM. London. Oxford University Press, 1919. Octavo; pages 136; cloth.

This book is a by-product of the war. Although lice have always existed, it is only the special multiplication under army conditions which has made them such a pest and such a menace to man as to make possible and popular the devotion of a book to their consideration. Notwithstanding this book is intended for the general reader rather than for the specialist, it is probable that all surgeons will belong sufficiently to the first class to make the book of interest to them, for it is not likely that the number of entomologists as specialists is so great as to count for much in the number of the readers which this book ought to have.

The louse has been the subject of intensive study to entomologists during the past few years, and certainly that which we have learned with regard to it warrants the statement that one of the most urgent sanitary problems of the future is the destruction and prevention of lice. Individual effort and organized public instruction should work together in disseminating knowledge of the dangers of this pest and of the methods in which it should be corrected and controlled. The author justly remarks in his preface that since it has been shown that many insects play an important part in the spread of diseases, it would be strange if the louse which shares our clothes, lives on such intimate terms with us, should not be incriminated. Recently acquired knowledge has shown that it must be ranked with mosquitoes and rat fleas in its malign influences. Typhus, one of the most dreaded diseases of man, is entirely due to its activities. Relapsing fever is caused by its spread and its labors, and the recent war has developed a new disease, trench fever, which must be referred to its discredit.

There are three species of lice which are found upon man, the head louse (*Pediculus capitis*), the body or clothes louse (*Pediculus corporis, seu vestimenti*), and the crab louse (*Phthirus pubis*).

Before the war the head louse was the only one with which the average person in this country was acquainted, as the pest occurring most frequently in children who became infected with them occasionally from conditions attending even the best regulated schools. The body louse in ordinary life was almost unknown, in the United States, at least. The stories passed down from our veteran troops in the relation of their Civil War experiences contained traditions of its prevalence and annoyance, especially in prison camps. In mediæval times, however, it was much more widely distributed, so that every one, from the highest to the lowest, was familiar with the pest, indeed, it was accounted a special virtue of certain saints that lice swarmed upon them and it was an ostentatious manifestation of their humility that they considered themselves unworthy to kill even so disgusting a product of creation as a louse.

Lice breed from pre-existing lice. However unclean in habit a person may be, unless he come in contact with one who is lousy or picks up a louse and is infected with one, he cannot become infested with them.

The louse propagates itself by eggs which are laid at the rate of 8 to 10 a day, and the egg-producing period continues for from twenty-five to thirty days, so that each pair of lice produce about 300 offspring of the first generation and many of these will have started to breed before their parents die, so that a female louse under conditions ideal from the louse's point of view might have about 4000 offspring before she dies. The average life of a louse, unless accidentally cut short, is from forty to forty-five days. As the days advance with her she becomes thin and anæmic, she ceases to breed or feed, continues for some days in a condition of senile lethargy and then gives up the ghost.

Lice are transmitted from person to person by contact, and especially by contact with infested clothing, body clothing, but more especially bed clothing. Cases are on record where single garments have held thousands of lice. Excluding such extreme cases the authorities tell us that of the men who have lice upon them, about 95 per cent. of them would have upon an average 20 to a man. The extreme, however, is in one case in which upon one shirt there were found 10,428 lice and 10,253 eggs.

Body lice, then, are found on men all over the world and there is probably no tribe free from them. They are, however, less prevalent in tropical than in temperate and cold climates, and in temperate climates they are less numerous in summer than in winter; these facts being correlated with the different habits of people in winter. In winter time people wear clothing of wool which is preferred by lice and such woollen garments are changed less frequently and people keep more indoors and crowd together, all of which conditions tend to favor the increase of lice whose life activities are best carried on at the body temperature.

One who is curious as to the life history and the habits of the louse will find much to interest him in this little book. The chapters which are given to the relations of the louse to relapsing fever and to typhus fever are of special importance and interest, especially as they show how perfectly possible by ordinary and simple hygienic measures it is to control the spread of these fevers which have been productive of such extensive fatal epidemics in the past.

One of the worst indictments of the medical service of the German army will ever be the sad story of the Wittenberg Prisoners Camp, where, owing to contact with Russian prisoners, typhus broke out among the imprisoned allies. At once all the German staff, both administrative and medical, abandoned the camp. The authorities cut off all necessary sanitary supplies and forbade any communication between the people outside and the unfortunate prisoners. The medical officer in charge, a certain Doctor Aschenbach (let his name ever hereafter be associated with that of Wirz of Andersonville ill fame), visited the camp only once during

the six months that the epidemic raged. Over 300 out of 800 prisoners who contracted the complaint died, and among them six medical officers of the British service, who were left unaided without supplies of any kind to grapple with the disease that prevailed about them. The Germans knew, as the world knew, that typhus was spread by lice and that the epidemic could have been cut short and stamped out a week after its commencement, by disinfection of all the prisoners, a procedure which the prisoners themselves would most willingly have performed had the necessary apparatus been provided; and when an appeal was made for such apparatus, they received in return simply an insult.

As to trench fever, it has been proved beyond doubt that lice are responsible for carrying the disease from man to man. It was not necessary, however, for a man to have been in the trenches in order to have contracted the fever. It was simply necessary that he should have been the subject of lice infection, the louse acting as a carrier of the germ in the blood of one sick man to the blood of the healthy man who was to become thereby infected. The preliminary work by means of which this was proved is described in the chapter devoted to Trench Fever, from which we learn the details of proof whereby it has been shown that the excreta of lice who have fed upon subjects already infected with trench fever, when rubbed into the broken skin of a healthy man, are capable of producing the fever in the person thus vaccinated. Such excreta may remain as dry dust in clothes or blankets for weeks or months and may be eventually rubbed into the wounds or scratches of one who has never known a louse. Not only skin abrasions may thus become the portals for this poisonous dust, but even the delicate membrane of the eye may be the portal through which an infection may be introduced.

The soldier who has the trench fever germ in his blood and harbors in his clothing lice, may become the indirect means of producing enough lice excreta to cause an attack of the disease in every man in his battalion, as the infected dust becomes spread abroad by the wind and falls upon his comrades.

We commend this little book to the interested study of every intelligent man.

LEWIS S. PILCHER.

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INDEX TO VOLUME LXIX

A

- Abdominal Drainage, 138; Lipomatosis, 556; Muscles, Fibroma of the, 600, 651.
 Acacia Gum and Glucose in the Treatment of Shock, 389.
 Adenomyoma of the Uterus, Frequency of, 135.
 Adhesive Plaster Method in the Treatment of Wounds, 291.
 ALBEE, FRED H.: Synthetic Transplantation of Tissues to Form New Finger, 379.
 ALLEN, FRANCIS OLCOTT, JR.: Pyloric Stenosis in Infancy, 531.
 Ambulance de l'Océan. La Panne, Belgium. Scientific Contributions from, Review of, 108.
 Amputation, the Guillotine, 543.
 Anastomosis of the Intestine, End-to-End, 613.
 Aneurism Needle, Double-eyed, 440; of the Temporal Artery, 334.
 Ankle, Complete Dislocation Without Fracture of Leg Bone, 650.
 Anuria after Unilateral Nephrectomy, 286.
 Appendices Epiploicæ, Torsion of, 31.
 Appendix, Vermiformis, Transplantation of, into Female Bladder to Supply Absent Urethra, 435.
 Arthritis Deformans Juvenilis, 47.
 Astragalus, Compound Dislocation of without Fracture of Leg Bones, 650.

B

- BAINBRIDGE, WILLIAM SEAMAN: Special Number of the United States Naval Medical Bulletin, Review of, 562.
 BARBER, W. HOWARD: Gas and Motility of the Surgical Stomach, 271.
 BAUER, E. L.: Diagnosis of Pyloric Stenosis in Infancy, 599.
 BECK, EMIL G.: Adhesive Plaster Method for the Rapid Regeneration of Skin over Granulating Wounds, 291.
 BEHREND, MOSES: Bone Saws, 176; Post-operative Infections of the Parotid Gland, 172; Variability of the Pathology and Symptoms of Chronic Intestinal Obstruction, 21.

- Biliary Drainage Outside the Body, Effects of, 58.
 BLACKMAN, R. H.: The Frequency of Adenomyoma of the Uterus, 135.
 BLAKE, JOSEPH A.: The Influence of the War Upon the Development of Surgery, 453.
 BLOODGOOD, JOSEPH COLT: Bone Tumors. Non-malignant Character of Giant-celled Tumor, 345.
 BOHMANSSON, GUSTA: Diagnosis and Therapy of Bone Typhoid, 245.
 Bone, Development of, Studies in, 360; Formation of, 225.
 Bone-grafts, 336, 337.
 Bone-saw Equipment, Masland's, 175.
 Bone-transplantation, Studies in, 113.
 Bone-tumors, 345.
 Bone-typhoid, Diagnosis and Therapy of, 245.
 Bones, Sarcoma of the Long, Conservative Treatment of, 550.
 Brain Wounds, Treatment of Secondary and Late Complications of, 184.
 Breast, Carcinoma of, Effect of Radium Upon, 555.
 BROOKS, BARNEY: Studies in Bone Transplantation, 113; Umbilical Teratoma, 603.
 BRUCE, SIR DAVID: Discussion on Tetanus, 564.
 BULKLEY, KENNETH: Fracture of the Femur, 466.
 BURGHARD, KANAVEL: The Oxford Loose-Leaf Surgery, Review of, 109.
 Burns, The Treatment of, 312.

C

- Cæcum and Ascending Colon, Resection of the, 25.
 Calculi in the Kidney, 173.
 Cancer of the Rectum; Abdomino-Sacral Operation for, 667; of the Superior Maxilla, Surgical Treatment of, 8.
 CANNADAY, JOHN E.: Long Resections of the Intestine, 425.
 Carotid Body, Excision of Tumor of the, 648.
 Cavities, Effacement of, in the Treatment of Fractures, 367.

INDEX

- Charcot Knee Complicated by Fracture of Leg, 171.
- Chinosol and Salt for Wound Treatment, 181, 493.
- Cholecystitis Following Typhoid Fever in Childhood, 534; Rare Pathognomonic Symptom of, 671.
- Cleft Palate and Harelip, Operative Treatment of, 12.
- Cloaca, Rectal, Permanent Operative, 606.
- COLEY, WILLIAM B.: Cases Illustrating Conservative Treatment of Sarcoma of the Long Bones, 550; Excision of Tumor of the Carotid Body, 649; Melanotic Sarcoma Disappearing Under Accidental Streptococcus Infection, 652; Repair of Inguinal Hernias, 659; Repair of Ventral Hernia, 658; Sarcoma of Tibia Disappearing under Toxin and Radium Treatment, 654.
- CONRAD, M.: Treatment of Chronic Osteomyelitis of Traumatic Origin, 82.
- COPHER, GLOVER H.: Deformity of Scapula, 645.
- Cranial Defect, Fascia Lata Graft for, 338; Repair of, 230.
- Cranioplasty, 61; Experimental, 384.
- CROTTI, ANDRÉ: Thyroid and Thymus, Review of, 110.
- ### D
- DEAVER, HARRY C.: Cholecystitis Following Typhoid Fever in Childhood, 534; Pyloric Stenosis in Infancy, 558.
- DEAVER, JOHN B.: Post-operative Infections of the Parotid Gland, 172; Post-operative Parotitis, 128.
- DE COURCY, JOSEPH L.: Complete Torsion of Great Omentum, 451.
- DEHELLY, GEORGES: Effacement of Cavities in the Treatment of Fractures, 367.
- DE KRUIF, PAUL H.: Experimental Research on the Effect of Intravenous Injection of Gum Salt Solutions, 297.
- DELREZ, L.: Treatment of Wounds of the Foot, 101.
- DEPAGE, ANTOINE: The Opening up of Gunshot Wounds, 95; Treatment of War Wounds, 575; Treatment of Wounds of the Foot, 101.
- Diaphragmatic Hernia, 254.
- Dichloramine-T, Use of, in a Series of War Wounds, 498.
- Dilatation, Acute, of the Stomach, 510.
- Disinfection with Chinosol and Salt, 493.
- DOUGLAS, JOHN: Excision of Tumor of the Carotid Body, 649; Fascia Lata Graft for Cranial Defect, 338; Operation for Fracture of Patella, 648; Removal of Enchondroma from Fibula, 336; Resection of Ulna for Osteomyelitis, 335; Resection of Upper Maxilla with Preservation of Hard Palate, 334; Ununited Fracture of Leg Treated by Bone Graft, 337.
- DOWD, CHARLES N.: Sterilizing Rubber Gloves, 340.
- DOWD, JOHN B.: Result of Polya-Balfour Operation for Carcinoma of the Stomach, 548.
- Drainage, Abdominal, 138.
- ### E
- ELMSLIE, R. C.: On the After-treatment of Wounds, Review of, 677.
- ELSBERG, CHARLES A.: Aneurism of the Temporal Artery, 334; Some Lesions Observed in Operations for Old Injuries to the Spinal Cord, 239.
- ELY, LEONARD W.: Legg's Disease, 47; The Formation of Bone, 225.
- Empyema Thoracis, 509; Chronic, 556; Streptococcus, Hæmolyticus in, 664.
- Enchondroma from Fibula, Removal of, 336.
- Epiploic Appendices, Torsion of, 31.
- ERDMANN, JOHN F.: Results of Polya-Balfour Operation for Carcinoma of the Stomach, 548.
- ERLANGER, JOSEPH: Hypertonic Gum Acacia and Glucose in the Treatment of Secondary Traumatic Shock, 389.
- EWING, JAMES: Neoplastic Diseases. A Textbook on Tumors. Review of, 342.
- ### F
- Fascia Lata Graft for Cranial Defect, 338.
- Fatty Hernias, 278.
- FAUNTLEROY, A. M.: Treatment of Burns, 589.
- Femoral Hernia, Lotheisen's Operation for, 432.
- Femur, Fracture of the, 466.
- Fibroma of the Abdominal Muscles, 600, 651.
- Fibula, Enchondroma of, 336.
- Finger, New, Formed by Transplantation, 379.

INDEX

FISCHER, HERMANN: Hydronephrosis Cured by Plastic Operation, 180; Lotheisen's Operation for Femoral Hernia, 432; Operative Treatment of Cancer of the Upper Jaw, 182; The Polya-Balfour Operation for Carcinoma of the Stomach, 548; Myxo-fibroma of Stomach, 663.

Fishbone Perforation of Intestine, 652.

FISHER, WILLIAM H.: Myxoma, 596; Primary Lymphosarcoma of the Intestines, 537.

Foot, Treatment of Wounds of the, 101.

Fracture of the Femur, 466; of Leg Complicating Charcot Knee, 171; of the Shaft of the Femur, Final Results of the Treatment of, 85.

Fractures, Effacement of Cavities in the Treatment of, 367; Involving Joints, Mobilization in the Treatment of, 212; of the Skull, Compound, with Open Dura, Treatment of, 1; of the Upper End of the Humerus, 147; Treated by Lane's Plate, Its Uses and Value, 161; of Patella, 647.

FRANK, LOUIS: Anuria After Unilateral Nephrectomy, 286.

G

Gall-bladder, Strawberry, Frequency of, 131; Surgery, Exposure in, 422; Gas and the Motility of the Surgical Stomach, 271.

GASSER, HERBERT S.: Hypertonic Gum Acacia and Glucose in the Treatment of Secondary Traumatic Shock, 389.

Gastromesenteric Ileus, Acute, 648.

Giant-celled Tumor of Ulna, Non-malignant, 345.

GIBSON, CHARLES L.: Advantages of Picric Acid for Disinfection of Skin, 127; Operation for Fracture of Patella, 647; Repair of Ventral Hernia, 657.

GOSSET: On Functional Results of Operations Upon Peripheral Nerves, 190.

GRAY: On the Early Treatment of War Wounds, 443.

GREEN, NATHAN W.: Chronic Empyema Thoracis, 557; Compound Dislocation of Astragalus Without Fracture of the Leg Bones, 650; Fibroma of Abdominal Muscles, 600, 651; Fractures of the Humerus with Paralysis of the Musculospiral Nerve, 338; Operations for

Femoral Hernia, 661; Repair of Inguinal Hernia, 432; Use of Rubber Gloves in Operative Surgery, 341.

Guillotine Amputation, 543.

Gum Salt Solutions, Intravenous Injection of, Experimental Research on, 297.

Gunshot Wounds, Opening Up of, 95.

H

HALE, KELLEY: Fatty Hernias, 278.

HARDE, E. S.: Frequency of Tetanus Bacilli Upon the Surface of Projectiles Extracted from Wounds, 68.

Harelip and Cleft Palate, Operative Treatment of, 12.

HARRIGAN, ANTHONY H.: Acute Dilatation of the Stomach, 510; The Use and Value of the Lane Plate, 161.

HARTWELL, J. A.: Operations for Carcinoma of the Rectum; Abdomino-sacral Operation for, 668; The Streptococcus Hæmolyticus in Double Empyema, 664.

HAWKES, FORBES: Tuberculosis of the Spleen, 56.

Hernia, Diaphragmatic, 254; Femoral, Lotheisen's Operation for, 432; Inguinal, 658; Hernia of the Vagina, 609; Ventral, Repair of, 657.

Hernias, Fatty, 278.

HITZROT, JAMES M.: Fracture of the Humerus with Paralysis of the Musculospiral Nerve, 338; Operations for Fracture of Patella, 647.

HOAGLAND, O. W.: Treatment of Burns, 589.

HOGUET, J. P.: Repair of Inguinal Hernia, 660.

HOLMES, GORDON: On the Treatment of Secondary and Late Complications of Brain Wounds, 184.

HORSLEY, J. SHELTON: Resection of the Cæcum and Ascending Colon, 25.

HOTCHKISS, LUCIUS W.: Operation for Fracture of Patella, 648; Repair of Inguinal Hernia, 660.

HULL, ALFRED J.: Handbook on Surgery, in War, Review of, 223.

Humerus, Fractures of the Upper End of the, 147.

HUNT, V. C.: Torsion of Appendices Epiploicæ, 31.

Hydronephrosis, Plastic Operation for, 180.

I

- Ileus, Acute Gastromesenteric, 648.
 Inguinal Hernia, 658.
 Intestinal Anastomosis, End-to-End, 613;
 Obstruction, Chronic, Variability of the
 Pathology and Symptoms of, 21.
 Intestine, Long Resection of the, 425.
 Intestines, Myoma of the Small, 663; Pri-
 mary Lymphosarcoma of the, 537.
 Intravenous Injection of Gum Salt Solu-
 tions, Experimental Research on the Ef-
 fect of, 297.

J

- JACOB, M.: Treatment of Chronic Os-
 teomyelitis of Traumatic Origin, 72.
 JANSSEN, CHARLES: Cranioplasty. Its In-
 dications and Technic, 61.
 Jaw, Upper Resections of, 178; With Pres-
 ervation of Hard Palate, 334.
 Joint Fractures, Mobilization in the Treat-
 ment of, 212.
 JOYCE, J. L.: Operative Treatment of
 Peripheral Nerve Injuries, 206.

K

- KEEN, WILLIAM W.: Case in Which for
 Over Thirty-five Years Fecal, Urinary
 and Menstrual Discharges Took Place
 Through the Rectum, 606.
 KEYES, A. BELCHAM: Remarks on Em-
 pyema Thoracis, 509.
 Kidney Calculi, 173.
 Knee, Charcot, Complicated by Fracture
 of Leg, 171.
 Knee-joint, Initial Treatment of War
 Wounds Involving the, 318.
 KURTZ, A. D.: Free Transplantation of
 Tendons, 450.

L

- LAMBERT, ADRIAN V. S.: Non-Parasitic
 Cysts of the Spleen, 15; Preliminary
 Ligation of External Carotid in Opera-
 tions for Cancer of the Upper Jaw, 182;
 Resection of Superior Maxilla, 179.
 Lane Plate and Bone Plastic Splints, Com-
 parative Merits of, 662; The Use and
 Value of the, 161.
 Leg, Ununited Fracture of Treated by
 Bone Graft, 337.
 Legg's Disease, 47.

- Lice and Their Menace to Man, LLOYD, L.
 Review of, 678.
 LILIENTHAL, HOWARD: Operations for
 Carcinoma of the Rectum: Abdomino-
 sacral Operation for, 669; Treatment of
 Empyema Thoracis, 665.
 Lipomatosis of the Abdominal Wall, 556.
 Liver Cirrhosis and Chronic Pancrea-
 titis, 36.
 LLOYD, L.: Lice and Their Menace to
 Man, Review of, 678.
 LOEWY, GEORGES: Effacement of Cavi-
 ties in the Treatment of Fractures, 367.
 Lotheisen's Operation for Femoral Hernia,
 432.
 Lung, Late Extraction of Missiles Im-
 bedded in the, 90.
 LUSK, WILLIAM C.: Disinfection of Vital-
 ized Tissues and the Healing of Wounds
 with Chinosol and Salt, 181, 493.
 Lymphosarcoma, Primary, of the Intes-
 tines, 537.

M

- MCDONALD, ARCHIBALD L.: The Treat-
 ment of Burns, 312.
 MACCARTY, WILLIAM CARPENTER: Fre-
 quency of Strawberry Gall-Bladder, 131;
 Frequency of Adenomyoma of the
 Uterus, 135.
 MAKINS, GEORGE M.: Treatment of
 Chronic Osteomyelitis of Traumatic
 Origin, 76.
 MANTZ, F. A.: Renal Calculi, 173.
 MASLAND, H. C.: Bone-Saw Equipment,
 175.
 MASSON, J. C.: Exposure in Gall-bladder
 Surgery, 422.
 MATHEWS, FRANK S.: Myoma of Small
 Intestine, 663; Abdominal Lipomatosis,
 556.
 Maxilla, Superior, Resection of, 178, 334;
 Surgical Treatment of Cancer of the, 8.
 METCALF, CARLETON R.: Initial Treatment
 of War Wounds Involving the Knee-
 joint, 318.
 MEYER, WILLY: Chronic Empyema Tho-
 racis, 556; Effects of Permanent Biliary
 Drainage, 58; Effect of Radium Upon
 Carcinoma of the Breast, 555; Hemor-
 rhage in Pyelo-Nephrolithotomy, 556;
 Operations for Carcinoma of the Rec-
 tum; Abdomino-sacral Operation for,

669; Operations for Femoral Hernia, 672; Rare Pathognomonic Symptom of Cholecystitis, 671; Result of the Polya-Balfour Operation for Carcinoma of the Stomach, 548; Thoracoplasty for Pulmonary Tuberculosis, 557.

MILLIKEN, SETH M.: Complete Dislocation of Ankle Without Fracture of Leg Bone, 650; Repair of Inguinal Hernias, 659.

Mobilization in the Treatment of Intra-articular Fractures, 212.

MOORE, SHERWOOD: An Error in Interpretation of Röntgenograms of the Skull, 4.

MORRIS, ROBERT T.: Injury of Musculospiral Nerve, 338; Notes on the Use of Rubber Gloves in Surgical Operations, 52; Operative Treatment of Cancer of the Upper Jaw, 182; Wound Treatment with Chinosol, 181.

Mouth, Bacterial Flora of the, 172.

Musculospiral Nerve, Injury of, 338.

Myoma of Small Intestines, 663.

N

Needle, Aneurism Double-eyed, 440.

Neoplastic Diseases, Review of JAMES EWING's Textbook on, 342.

Nephrectomy, Unilateral, Followed by Anuria, 286.

Nerve, Injuries, Peripheral, Results of Operations Upon, 206.

Nerve, Musculospiral, Injury of, 338.

Nerves, Peripheral, Functional Results of Operations Upon, 190.

NEW YORK SURGICAL SOCIETY, Transactions of the, 56, 178, 331, 548, 652, 663.

NIAS, J. B.: Sketch of the "Life of Dr. John Radcliffe," Review of, 561.

NICOLL, JAMES H.: Operative Treatment of Harelip and Cleft Palate, 12.

Nose, Carcinoma of the, Rhinoplasty for, 667.

O

Obstruction, Chronic Intestinal, Variability of the Pathology and Symptoms of, 21.

OLIVIER, R.: Late Extractions of Missiles Imbedded in the Lung, 90.

Omentum, Great, Complete Torsion of, 451.

Opening up of Gunshot Wounds, 95.

ORR, THOMAS G.: The Guillotine Amputation, 543.

Osteogenetic Power of a Free Bone Transplant, 113.

Osteomyelitis, Chronic, of Traumatic Origin, 72; of Ulna, Resection, 335.

Oxford Loose-Leaf Surgery, Review of, 109.

P

Pancreatitis, and Cirrhosis of the Liver, 56.

Parotid Gland, Post-operative Infections of the, 172.

Parotitis, Post-operative, 128.

Patella, Fracture of, Operation for, 647.

PECK, CHARLES H.: Drainage in Empyema, 667; Fibroma of Abdominal Muscles, 651; Intratracheal Anæsthesia in Operations Upon the Upper Jaw, 182; Operations for Carcinoma of the Rectum; Abdomino-sacral Operation for, 670; Plastic Operations for Hydronephrosis, 181; Repair of Inguinal Hernias, 661; Repair of Ventral Hernias, 658.

Perineal Prostatectomy, 331.

PHILADELPHIA ACADEMY OF SURGERY, Transactions of the, 171, 551.

Picric Acid, Advantages of, for Disinfection of Skin, 127.

PILCHER, LEWIS S.: The Influence of War Surgery Upon Civil Practice, 565; Review of GRAY on the Early Treatment of War Wounds, 443.

Prostatectomy, Perineal, 331.

Pyelo-Nephrolithotomy Followed by Secondary Hemorrhage, 556.

Pyloric Stenosis in Infancy, 531, 558.

R

RADCLIFFE, JOHN: Sketch of His Life, with an Account of His Fellows and Foundations. By J. B. Nias. Review of, 561.

Renal Calculi, 173.

Resections, Long, of the Intestine, 422.

Rhinoplasty for Carcinoma of the Nose, 667.

ROBERTS, JOHN B.: Charcot Knee Complicated by Fractured Leg, 171; Erroneous Interpretation of X-ray Plates, 171; The Segment Trephine, 176.

ROGERS, JOHN: Recurrent Ulcers of the Stomach, 549.

- Röntgenograms of the Skull, Source of Error in Interpretation of, 4.
 ROSSER, CHARLES M.: Transplantation of Vermiform Appendix Into Female Bladder to Supply an Absent Urethra, 435.
 Rubber Gloves, Notes on the Use of, in Surgical Operations, 52; Sterilization of, 340.
 RUGH, J. TORRANCE: Masland's Bone Saw Equipment, 176; Mouth Bacteria, 172.
 RUSSELL, JAMES I.: Treatment of Empyema Thoracis, 666.

S

- SACHS, ERNEST: Treatment of Compound Fractures of the Skull with Open Dura, 1.
 Sarcoma, Melanotic, Disappearance Under Accidental Streptococcus Infection, 652; of the Long Bones, Cases Illustrating Conservative Treatment of, 550; of Tibia Disappearing Under Toxin and Radium Treatment, 654.
 Scapulae, Deformity of, 645.
 SCHLEY, WINFIELD S.: Excision of Tumor of the Carotid Body, 649; Fishbone Perforation of Intestine, 652; Operative Treatment of Cancer of the Upper Jaw, 178, 182; Surgical Treatment of Cancer of the Superior Maxilla, 8.
 Segment Trephine, 176.
 Septicæmia, Treatment of, by Transfusion of Immune Blood, 437.
 Shock, Secondary Traumatic Hypertonic Gum Acacia and Glucose in the Treatment of, 389.
 SINCLAIR, DONALD B.: Fracture of the Femur, 466.
 SKILLERN, PENN G., JR.: Operation for Fracture of Patella, 648; A Series of War Wounds Treated with Dichloramine-T, 498.
 Skin Disinfection with Picric Acid, 127.
 Skull, Repair of Defects of the, 230.
 SORESI, ANGELO L.: Diaphragmatic Hernia, 254; Double-eyed Aneurism Needle, 440; End-to-End Intestinal Anastomosis, 613.
 Source of Error in Interpretation of Röntgenograms of the, 4; Treatment of Compound Fractures of the, with Open Dura, 1.
 Spinal Cord, Operations for Old Injuries to, 230.

- Spleen, Non-Parasitic Cysts of the, 15; Tuberculosis of the, 56.
 Stenosis of the Pylorus in Infancy, 531, 558.
 STEVENS, J. H.: Fractures of the Upper End of the Humerus, 147.
 Stomach, Acute Dilatation of the, 510; Carcinoma of the, Results of the Polya-Balfour Operation, 548; Fibrolipoma of the, 663; Recurrent Ulcer of the, 549; Surgical, Gas and the Motility of the, 271.
 Strawberry Gall-bladder, Frequency of, 131.
 Surgery in War, Handbook on, by ALFRED J. HULL, Review of, 223.
 "Surgical Treatment," by JAMES PETER WARBASSE, vol. ii, Review of, 222.
 SWEETSER, HORATIO B.: Vaginal Hernia, 609.
 SYMS, PARKER: Perineal Prostatectomy, 331; Rubber Gloves in Operative Surgery, 340.

T

- TAYLOR, ALFRED S.: Effects of Biliary Drainage Externally, 58; Fracture of the Humerus with Paralysis of the Musculospiral Nerve, 338.
 Tendons, Free, Transplantation of, 450.
 Teratoma, Umbilical, 603.
 Tetanus, SIR DAVID BRUCE on, 564; Bacilli, Frequency of, Upon the Surface of Extracted Projectiles, 68.
 "Thyroid and Thymus," by ANDRÉ CROTTI, Review of, 110.
 Tongue, Extirpation of for Carcinoma, 671.
 TOREK, FRANZ: Carcinoma of the Rectum; Compound Abdomino-sacral Operation, 667; Extirpation of Tongue for Carcinoma, 671; Operations for Femoral Hernia, 673; Rhinoplasty for Carcinoma of the Nose, 667.
 Torsion, Complete, of Great Omentum, 451.
 Transfusion of Immune Blood in the Treatment of Septicæmia, 437.
 Transplantation of Bone, Studies in, 113; Free, of Tendons, 450; of Tissues to Form New Finger, 379.
 Trephine, the Segment, 176.
 Tuberculosis, Pulmonary, Thoracoplasty for, 557; of the Spleen, 56.

INDEX

TUFFIER, THEODORE: Final Results of the Treatment of Fractures of the Shaft of the Femur, 85.

Tumors of Bone, Giant-celled Non-malignant, 345.

Typhoid, Affections of Bone in, Diagnosis and Therapy of, 245; Fever, Surgical Aspects of WEBB-JOHNSON, Review of, 674; in Childhood Followed by Cholecystitis, 534.

U

Ulna, Resection of, for Osteomyelitis, 335.

Umbilical Teratoma, 603.

United States Army X-ray Manual, Review of, III; Naval Medical Bulletin. Special Number. By WILLIAM SEAMAN BAINBRIDGE. Review of, 562.

Urachus, Cyst of the, with Concretion Enclosed, 329.

Urethra, Absent, Supplied by Transplantation of Vermiform Appendix, 435.

Uterus, Adenomyoma of the, The Frequency of, 135.

V

Vaginal Hernia, 609.

Ventral Hernia, Repair of, 657.

Vermiform Appendix, Transplantation Into Female Bladder to Supply Absent Urethra, 435.

W

War, The Influence of the, Upon the Development of Surgery, 453; Surgery, the Influence of, Upon Civil Practice, 565.

WARBASSE, JAMES PETER: Treatise on Surgical Treatment, vol. ii, Review of, 222.

WARD, WILLIAM G.: Suppurating Cyst of the Urachus with Concretion, 329.

War-Wounds, The Early Treatment of, Review of GRAY on, 443; Treated with Dichloramine-T, 498; Treatment of, 575.

WEBB-JOHNSON on The Surgical Aspects of Typhoid Fever, Review of, 674.

WEGFORTH, PAUL: Note on Experimental Cranioplasty, 384.

WHARTON, HENRY R.: Pyloric Stenosis in Infancy, 558.

WHIPPLE, A. O.: Liver Cirrhosis and Chronic Pancreatitis, 56.

WIENER, JOSEPH: Comparative Merits of Lane Plates and Bone Plastic Splints, 662; Excision of Tumor of the Carotid Body, 648; Fibroma of Abdominal Muscles, 651; Operation for Fracture of Patella, 647.

WILLEMS, CHARLES: On Mobilization in the Treatment of Intra-articular Fractures, 212.

WILSON, GEORGE EWART: The Repair of Cranial Defects, 230.

WOOLSEY, GEORGE: Giant-celled Sarcoma of Femur, 555.

Wounds, Granulating, Adhesive Plaster Method for Securing Rapid Regeneration of Skin Over, 291; Healing of, with Chinosol and Salt, 493; After-Treatment of, Review of ELMSLIE on, 677.

X

X-ray Manual of the United States Army, Review of, III.

